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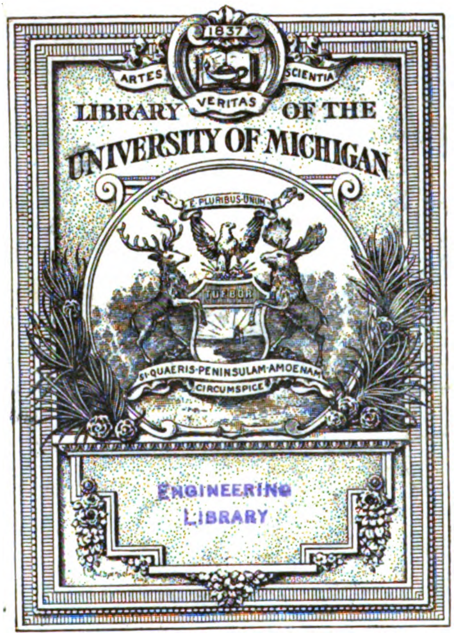

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VOLUME V.

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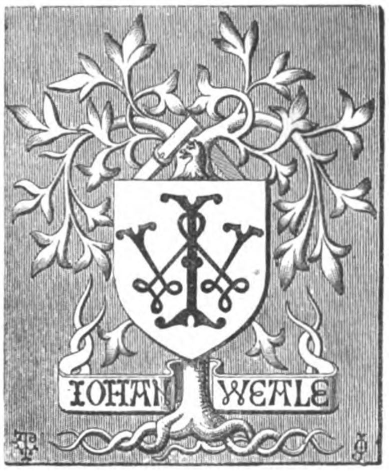

LONDON:
No. 59, HIGH HOLBORN.
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TO

ROBERT STEPHENSON, ESQUIRE,

CIVIL ENGINEER, F.R.S., M.I.C.E., ETC., ETC., ETC.,

THIS VOLUME,

ON SUBJECTS FOR WHICH HE IS SO EMINENTLY DISTINGUISHED,

IS INSCRIBED,

WITH GRATEFUL RECOLLECTIONS, BY HIS VERY HUMBLE SERVANT,

JOHN WEALE.

JUNE 1ST, 1846.

136127

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TO THE BINDER.

Sheet F of "Part X.—Eng. I." has been accidentally printed off numbered "Part IX.;" but a reference to the folios will prevent any mistake.

The detached "Preface" belongs to the Paper on the "Progress of Machinery and Manufactures."

PREFACE.

THE following notices have been collected with an intention to form an outline of the first period of English mechanical and manufacturing ingenuity. Wherever it could be done, with reference to the necessary brevity, the original statements have been transcribed, as being in many cases illustrative of the manners of the times, as well as descriptive of the invention, without any thing further being attempted beyond that of giving the transcripts a methodical arrangement.

It was considered that a very imperfect notion of our progress in manufactures could be produced, unless some notice were taken of the discussions which during half a century periodically took place in parliament on the abuse of the royal grants of letters patent. The limits of this sketch, however, do not admit these interesting transactions to be mentioned, except in the briefest manner only. It need hardly be observed that all compilations of this kind must be comparatively incomplete where free access cannot be had to the original records. The exorbitant fees exacted for permission to inspect documents enrolled in the Patent Office operate, to all intents and purposes, as an effectual exclusion of mechanical men from the store of information contained in thousands of minute descriptions and drawings of inventions and improvements of every kind, which have been *deposited in that office by patentees* for the sole purpose of being *seen and perused,* in order that the knowledge, use, and benefit of their inventions should be spread throughout the community. Before a moiety even of the precious records, the titles of which have been enumerated in this outline, can be examined, several hundred pounds must be spent in fees. Nevertheless, in spite of such and other obstacles, it is hoped that this *first attempt* to produce a chronological sketch of the early stage of English mechanical invention and enterprise will be found to exhibit a clear and satisfactory, though confessedly a very circumscribed, view of a subject of great importance.

M

THE

PROGRESS

OF

MACHINERY AND MANUFACTURES

IN

GREAT BRITAIN,

EXHIBITED

IN A

CHRONOLOGICAL LIST OF LETTERS PATENT

OF

INVENTIONS AND IMPROVEMENTS,

FROM THE

EARLIEST TIMES TO THE PRESENT.

THE PROGRESS OF THE MACHINERY AND MANUFACTURES OF GREAT BRITAIN.

CHAPTER I.

THE low state of the mechanic arts among the earlier Britons is seen in the rudeness of their weapons. Their bows and arrows were made of reed headed with flint, or pointed with bones sharpened to an acute edge. Their quivers were of osier twigs. Spears and javelins were formed of long bones ground to a point, and inserted into a shaft of oak. A battle-axe of flint and a club of oak, called a "cat," which had four points or edges, completed their martial equipment.

After these savages were "discovered" by the Phœnicians, the use of flint and bone gave way to that of tin and copper. When they adopted the sword, which was long, and blunt at the end, they fashioned its hilt of horn; hence the ancient proverb, "He that has got the horn has got the blade." Their short spears had a bell at its lower end, which they shook with great violence to intimidate their enemies in battle; and their small bucklers were formed of hides. Their war chariots were of three kinds;—the rheda and the essedum seem to have been merely carts or waggons, forming moveable stages to fight from; the covins, constructed for aggression, were armed with hooks and scythes, set into their axletrees. The keels and ribs of their boats were of some light wood, covered with leather, or they were formed of intertwined osier twigs, cased with hides, and rigged with leather sails, which were fixed to the mast and never furled, and the tackle was of thongs. Small armies were transported in these from Britain to Gaul and Ireland. Even the maritime and commercial Veneti of Gaul used such ships, with iron chains for cables. With respect to clothing, they were nearly in a state of nature, partially veiling their nakedness with skins. They used woad to stain their bodies blue, that they might seem fiercer to their enemies. The natives of Cornwall are described as digging tin during ebb tide out of the rocks forming the coast and estuaries. It is probable they also sought for it in inland mines under the superintendence of their civilized customers. The Phœnician trade to Britain seems to have been conducted wholly over sea, and to have been most lucrative. And for three hundred years they concealed the source whence they procured the tin with great care. Strabo says that a Phœnician ship thinking itself pursued by a Roman, chose to run upon a shoal and be wrecked, rather than disclose the tract by which any other nation could come in for a share.

In exchange for the tin, copper, lead, cattle, corn, slaves, dogs, muscle pearls, polished horse bits of bone, amber toys, and glass vessels like bottles and basins, and wool, the Britons among other things received brazen articles, crockery and salt. A few years before the destruction of Carthage, the Greeks of Marseilles found their way to Cornwall, and became the chief traders in its staple articles. The traffic afterwards in the hands of these merchants passed wholly overland. The Veneti transported the tin and other produce of the Belgæ to the opposite coast, where it was unshipped, and conveyed on horses through Gaul, or by boats along its rivers to Marseilles and Narbonne. Iron works were carried on by the Belgæ a few years before the arrival of Cæsar.

The arts of the Roman Britons were soon assimilated to those of the nation dominant. The colony excelled in the manufacture of iron. The legions had their particular *fabri*, who had their workshops in their camps and stations, and also in towns, for general purposes. The craft was formed into companies or colleges, endowed with certain privileges, and each governed by its own primicerius or head. No person was allowed to forge arms unless he was an admitted member of the Collegium Fabricæ, or he was prohibited from leaving the service until he had risen to its chief office; and that he might not desert it, a mark was impressed on his arm. These military smiths carried their art to great perfection. And as early as 121, a fabrica or college of them was established at Bath. It is conjectured with much probability that a Roman foundry existed as far north as the station at Dick's House on the Vallum Antonini, within a few miles of the present celebrated Carron works. Pewter became known to the Italians when Agricola was in Britain. At its first introduction it sold at four shillings and ten pence per pound in Rome, and was known as the "silvery metal." In the third century the Highland Caledonians had a manufacture of coarse woollen cloth, or plaiding; the striped mantles made of it were called breacan.

Roman body armour worn in other provinces of the empire was generally of brass,

brass swords and scabbards were common. Iron was considered to be an inferior material; and Tacitus says, Otho wore a breastplate of that metal, to show his humility. The Romans had an impression that wounds made by iron weapons were poisoned, a feeling that in modern times is reversed. The testimonies of writers, and repeated exhumations of arms, show that in Britain iron was the general material of which they were formed. In the Roman army, the British legions that were clothed in skins, had steel weapons, as a characteristic part of their national costume[a]. Their steel-bladed swords were often ornamented with hilts of brass, and copper.

There was a trade in trinkets in the island. Augustus taxed ivory boxes, iron chains, and many other ornamental articles. The British agates or jet ornaments were the finest then known. The silvery marle or chalk of Kent and Essex was, according to Bede, shipped as manure to marshy districts on the Rhine. Among the imports were sugar, pepper, ginger, and writing paper.

Some of the Roman arts necessarily depending on a high degree of luxury and wealth in the community, must have been discontinued during the Anglo-Saxon period, from the altered circumstances of the people. There are good grounds, however, for believing that the more useful arts were generally practised; though not with the perfection of Roman times. The advantages, it has been observed, reaped by the Anglo-Saxon society from tradesmen, whether dealers or manufacturers, were small. They were neither numerous, nor wealthy, nor civilized, and were mostly in a servile state. The domestics of the great and wealthy were trained to supply them with the articles in common use, and men of property rewarded their servants who excelled in different handicrafts. In a monastery we find smiths, carpenters, millers, illuminators of books, architects, agriculturists, and even fishermen. Mechanic skill was much valued, and its possession reckoned honourable. Many of the higher clergy made a merit of being good artificers. When Dunstan ruled England, under Edwy the Fair, he had a forge in his bedroom: once on a time Satan thrusting his head through the small window to palaver, the clerical amateur dexterously seized the intruder's nose with red-hot smith's tongs, and the yells of the agonized demon were heard throughout the district. The smith in this, as in other mainly pastoral communities, was a person of great importance. The sword smith, or armourer, in particular, was in high estimation. In ancient records his name is frequently added to the arms he fabricated, as a mark of their superior excellence and value. The sword blade was of iron or steel, long, broad, straight, and double-edged. Men of rank possessed a number of these weapons. Prince Athelstan bequeaths nearly a dozen. Silver-hilted swords are specified, and also hilts of gold, and gilt hilts, and hollow hilts, and sword belts adorned with gold, silver and jewels. Danish swords were like those of the Anglo-Saxons, but more ornament was put on the scabbard. Their helmets were mostly of leather. Speed says, cross bows were used by the Anglo-Saxons. That the cross bow was known as an arm of some of their neighbours, in the period near the conquest, is certain; but as it does not appear, according to Strutt, in any ancient history or delineation connected with this people, it is not likely ever to have been a weapon used in the country. Common slight body armour may have been fabricated by native smiths, and the shoemaker, but the finer specimens of this beautiful art were the production of foreign armourers. The intercourse of the Anglo-Saxons with the Greek emperors apparently made them adopt the Phrygian tunic, covered with flat rings; the armour itself in all likelihood came from the Greek emporium of much of every thing that in these times was exquisite in taste and in workmanship.

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[a] The Spaniards in these ages were famed for their skill in sword making. Diodorus Siculus says, "They make their swords and darts in an admirable manner, for they bury plates of iron so long under ground as is necessary for the rust to consume the weaker part, and therefore use only that which is strong and firm. Swords and other weapons are made of this prepared steel, and these are so powerful in cutting, that neither shield, helmet, or bone, can withstand them."

The manufacture of glass was, about 670, attempted to be introduced into Northumberland, by Benedict Biscopius. Some glass blowers were brought from Gaul by this public-spirited and pious monk, whose taste for comfort had much outrun that of his countrymen. As far as regards the manufacture of *window-glass*, the furnaces seem quickly to have been permanently extinguished for upwards of eight hundred years.

The Anglo-Saxons had wheel carriages for riding in, and a sort of four-wheeled hammock, and their farm carts had spoked wheels: they had spades, scythes, sickles, hay-forks, ploughs with one handle and without wheels and coulter. The ploughman held the handle with one hand and broke the clods with a spade or a club in the other. The horse harness or graithing was similar to ours. There is a charter extant of Ulfere in 664, for the foundation of the monastery of Medeshamstede, in which water corn-mills are mentioned.

Ale is mentioned in the laws of Ina, king of Wessex, about 690, and was one of the beverages at a banquet provided for Edward the Martyr in 976.

The use of expensive foreign furs was considered to be a mark of distinction, and their preparation was carried on as a trade. Cups and basins and spoons were formed of horn. A cup or "horn of pottage" was always presented to a visitor. Bottles also were made of horn, as well as of leather. For nearly a thousand years after this period, and when bottles were made of clay or glass only, the horners and bottle makers, an union that sounds odd to modern ears, formed one gild or fraternity.

Next to the smith may be ranked the shoemaker, or rather the worker in leather. This protean artist united in his own person the trades or mysteries of shoemaking, trouser and doublet making, or tailoring, bottle, hose, saucepan and boiler making, knapsack or wallet making, whip making and halter making. He was also called on to produce sword scabbards, shields, helmets and loricæ, and saddles; but this latter was a simple department, for it was little more than a sack strapped to the horse's back. The ladies rode sidewise, as they do now, but their delicate legs had not the artificial aid that is given by a modern side-saddle—their seat was a mere pillion.

Lead was used for the covering of buildings, and was certainly found at home; but the Anglo-Saxons wholly neglected the tin mines, or employed "Arabs or Saracens," most probably Germans, in them. There were iron works near Gloucester in the time of Edward the Confessor, and which in all probability had been kept up from Roman times. The city of Gloucester paid him, among other things, thirty-six dicres of iron, each of ten bars, and one hundred rods of iron drawn out, for the nails of the king's ships—or iron rods wrought to a fit size to make nails.

They coined money in most of the principal towns. Edward the Elder had seven mints in Canterbury, three in Rochester, eight in London, six in Winchester, two in Lewes, two in Hastings, and one in Chichester, and in every good town one coiner. From this it is clear that it was a profitable trade. The coin was very coarse, and made by hammer on the anvil, and had a rude impress in relief given by a die.

The dressing and spinning of wool, and weaving and dyeing and ornamenting cloth, were practised with success. "The shuttle," says William of Malmesbury, "is not filled with purple only, but with various colours moved here and there among the thick-spreading threads, and by the embroidery art they adorn all the woven work with various groups of figures." The Anglo-Saxon ladies were brought up to spin; and Edward the Elder sent his "son to scole and his daughter to worke wole," or to be taught the use of the distaff and the needle. The Anglo-Saxon women became so famous for their taste and skill in embroidery with threads of coloured silk and of gold and silver, that in foreign countries the ornamented cloth was called "English work," as in former times a similar fabric was called Phrygian. They excelled also in feather-work, a precious kind of embroidery in which feathers were inserted with the needle or in the loom, so as to form a pattern in the rich cloth called baudekin. The ladies' garments were chiefly of linen, with broad trimmings of various colours; the men's, of the lower rank, of leather. The weavers also made a cloth from the fine threads of goat's hair, which was used by the clergy for bedding, and occasionally for shirts by devotees, which were noted to be difficult to keep free of vermin.

The gold and silver smiths were made eminent in their calling from the great demand among the Anglo-Saxon ladies for trinkets, which increased so much afterwards as to attract many German artists to assist in supplying them.

The tastes and crafts of the people are somewhat indicated by the list of imported articles, among which are found skins, or rather furs, silks, gems, gold, various descriptions of garments, pigments, wine, oil, ivory, orichalcos, and silver, and what would certainly be least expected, copper and tin. Iron was sufficiently abundant to have been exported at all times. According to Camden, a considerable quantity of the finest salt in Europe was made on the shores of Britain in the fourth century. It was also manufactured at Droitwich in 816; in that year Kenulph, king of Mercia, gave salt-works to Worcester church.

The Anglo-Saxons navigated the Irish Sea in skiffs like those of the Britons, made of osier twigs covered with hides. In the sixth century we see a vessel lined with leather, fitted and rigged with oars and sails, which had several mariners on board, scudding before a storm for fourteen days without foundering, carried to the north beyond the track of former navigators, and yet reaching her destined port in safety. From their construction they could hardly have accommodated more than from four to six persons. Their numbers, however, made up on warlike occasions for their small size. Speed says Edgar's navy was composed of 3,600 ships, and if we read "boats," the number would be credible. Some time before the conquest they began to build them of planks of wood and to deck them over. The Danish boats were originally a sort of bark with twelve oars. Under Hardicanute they were capable of holding 120 men. They were acquainted with the construction and use of canals. That called Kingsdelf, in Huntingdonshire, is certainly as ancient as the year 963. It has been referred to by some as a Roman work, but not on very good grounds.

The Anglo-Saxons exported wool to Germany, where it was highly prized. In 1050, the emperor, Henry III., conferred the burggraviate of Nimeguen upon the Count of Cleves, on condition of his delivering to him yearly three pieces of scarlet cloth made of "English wool."

In the eleventh century, the silver coins of native reguli have inscriptions in relief in the Irish character and language. At the commencement of the twelfth century the Irish appear to have been skilful in the manufacture of swords. About 1108, Fuller says, that Coucy, Earl of Ulster, in the presence of King John, and King Philip Augustus of France, cut through a helmet of steel with one blow of his sword, and struck the weapon so deeply into the post on which it was placed, that no one but himself was able to withdraw it. At the same period a coarse sort of parti-coloured woollen cloth was made in the country, and wool in small quantities was sold to the Germans or Flemings.

About 1040, in the reign of Hardicanute, the best ale was sold at eightpence the gallon. It was spiced with cloves to preserve it.

In course of time, the king and nobles getting poorer and more dependent, many of the Anglo-Saxon bondmen, who formed the bulk of the traders and mechanics, acquired their freedom, by purchase and other means. They then became farm labourers and proprietors, or settling in towns under the protection of the king, paid him rent or service as burghers. The gilds and corporations of which they then became members resembled our benefit societies, with entrance fees, fines, and periodical payments. Their rules were also framed to encourage good fellowship, and to distinguish them from modern gilds, the historian adds, "at their own expense." They are the unexceptionable types of the trade gilds or corporations that afterwards spread over the country.

In glancing backwards on the Anglo-Saxon dominion, now drawn to its close, individual and public wealth are observed to have steadily increased, from the extinction of the Heptarchy to the battle of Hastings. That the conquest greatly retarded the national progress towards a development of its inherent sources of commercial greatness, has been inferred from the fact, that its manufactures continue to increase in spite of the ruinous and often iniquitous contests in which the country was plunged, through its unpropitious connexion with the Norman line of princes.

1066. After the conquest English gold and silver articles were so much improved by some foreigners who settled in London, that they acquired a name in other countries. Anketil, one of these workmen, was invited to superintend the "gold works" of the King of Denmark. The Anglo-Norman ladies vied with their predecessors for skill in embroidery, and some of the tapestry now becoming an ornament to the walls of the baron's hall may have been produced by their labour. Italian and Greek silks were imported, and used in the garments of the noble and wealthy of both sexes. Sandal, or candal silk, a very fine and rich sort, was highly esteemed in these ages. Some of the wool exported was returned in cloth. In the Conqueror's time that made in Flanders was prized in every market, and the industrious Flemings were enriched by its manufacture; and so great was their skill in cloth making, that "it seemed in them," says Gervas, "to be almost a gift or instinct of nature." A great number of these artisans being driven out of their own country by an inundation of the sea, were led to seek protection and a settlement from William, from the circumstance of his queen being their countrywoman. They are described as brave and hardy, able to handle with energy both the plough and the sword, and besides most skilful in the mystery of making the coveted staple commodity of their country. This invaluable colony, the founders of the woollen trade of England, the Conqueror settled at Carlisle; but the ill-will and jealousy of their semi-barbarous neighbours constantly involving them in broils and quarrels, they were, in 1111, removed by Henry I. to Ros, now a part of Pembroke, where their posterity can be distinguished from the surrounding Welsh at the present day.

With the Conqueror was introduced the practice of shoeing the battle-horse with iron shoes fastened with nails. They were reckoned valuable; and he gave Simon St. Liz the town of Northampton, valued at £40 a year, on condition of providing shoes for his horse. The horse-smith was also a man of consideration. Henry de Ferrers accompanied William as foreman of the farriers, (*præfectus fabrorum,*) and the employment was considered by his descendants to be an honourable distinction, which they commemorated by assuming the designation of their ancestor's craft as their sirname.

The erection of royal and baronial castles throughout the kingdom could hardly fail to improve the arts connected with architecture. The edifices of this period which are still existing give an exalted notion of the great skill of the Anglo-Norman masons, and to them is due the introduction of the invention that most distinguishes this from preceding ages. At the close of the reign of Henry I. a new manner of building was produced, by the adoption of a novel form of arch. The openings of doors and windows, and of vaultings generally, are pointed, or shaped in outline like a lancet. This peculiarity carried throughout the system of construction and decoration, gives the character which is called the Gothic, the English or the Pointed Style, to a building,—a style which in all its stages towards full development, exhibits a combination of parts of exquisite beauty and propriety, with others of positive ugliness and absurdity.

Attention to internal improvement was shown by Henry I. when he made a navigable canal seven miles in length, from the Trent at Torksey to the Witham at Lincoln, into which he conducted the water of the Trent. In his reign there occurs, according to Madox, the earliest notice of a trading gild, or fraternity; an institution which soon exerted a great influence on civic capital and labour, and which is suffered, in our times, to hurt and fetter both.

1108. Henry I. coined round halfpennies and farthings. Previous to this pennies had sometimes been made with a cross indented, and the coin was broken to give a half or quarter of it.

1109. Ale manufactured in Scotland; "during the intense frost of this year it is stated to have been sold by weight." Alexander I. invited English merchants to settle in his towns.

1120. Pearls found in Scottish rivers prized in foreign countries for their size and beauty.

1131. The coinage still very rude. "During the civil wars under John there were as many kings as lords of castles, each," says Hemingford, "having his own proper money." Domesday Book mentions the name of Otto, a goldsmith, as a die-sinker, or engraver, for the king's money. This appointment, apparently hereditary, continued in his family for 200 years.

The Normans, in 1135, attempted the art of embalming. Henry I., according to Trevisa, "being dede, hys bowels were drawne oute of his bodye, and his brayne taken oute of hys heede, and the bodye salted wyth moche salte; and for to avoide the stenche that hade ynfectede many mene yt was at last closede in a hoole skynn."

1143. Wind and water mills for grinding corn mentioned as being common in Northamptonshire.

1153. A silver mine was worked in Cumberland by King David. At this date the Scots had a fishery in the Forth. Scottish towns were filled with English inhabitants, who made woollen cloth. They had also introduced the gild regulations. None but burgesses were to buy wool for dyeing, or making into cloth; nor were foreign merchants permitted to buy wool from any but burgesses.

1155. Linen cloth used for men's garments. The body of Henry, son of Henry II., "was wrapped," according to the chronicler, "in those very linen clothes that at his coronation were embrued with holy oil." It was probably manufactured by the Flemings, who were famous at this time for linen fabrics.

1156. The Irish fabricated a "pepper and salt" coloured cloth of the natural black and white wool, besides some coarse dyed fabrics for plaids and trowsers. Their iron lances, javelins, and battle-axes, made in the country, were famed for being excellently tempered. At this time, perhaps, these articles comprise the whole of their manufactures.

1164. Silk, or bombycina, made by silk worms, which first came out of Greece into Sicily, "was," says Camden, "brought into use near this period."

1165. About this time alcohol described, perhaps discovered, "and the art of distillation introduced, it is believed, into England. It was shortly afterwards better understood in Ireland than anywhere else."

1180. Water-driven corn mills general in Wales;—one of the benefits resulting, perhaps, from an imitation of the Anglo-Fleming colony at Ros.

Fitzstephen, secretary to Thomas a'Becket, describes the skates used by the Londoners to be made of bones strapped to the shoes.

The Anglo-Saxon saddle was a mere pad, easily shaped and put together. The Norman saddle rose high before and behind, and required much skill to mould the saddle-tree, and fit the whole, as well as taste in ornament, for the whole furniture partook of the splendid character of the arms and body armour of the horseman.

The tanner's art has not yet been noticed, though from the almost universal use of leather in the dress of the people, and by saddlers and armourers, it must have long been one of importance. Skins, under which were comprehended furs, are seen among the imports, perhaps they were the finer sorts of stained leather. The staple article was manufactured at home—though raw hides were often exported. Foreign furs were in general use, and reckoned a mark of luxury. The twelfth canon of the statute made at London in 1127, enacts that abbesses and nuns were to wear furs made only of cat-skins, or of lamb-skins.

Glass-making was unknown, and churches, castles, and houses had no glazed windows, but the openings for light were filled with lattice-work, oiled linen, or horn. Chimneys were known, but except in rare cases they were not used. Lead was a common covering for roofs. The massive furniture, the forms, stools, and tables and bed-posts, were most likely made by the native joiner. The carpenter had often a warlike aspect. The Conqueror, according to Verstegan, on his landing in England, set up three castles, or towers of wood, which had been framed and finished in Normandy.

Queen Matilda built a *stone* bridge over the Lea. " A rare piece of work," says Stow; " the like before had never been seen in England."

Camden states, that woollen fabrics were called *worsteds*, from being first made in any quantity at a village called Worstede, in Norfolk. The manufacture was introduced there by some Flemings in the time of Henry I., perhaps about 1120.

1189. The great quantities of wool exported from England excited the admiration of Matthew Paris, who observes—" That all the nations of the world were kept warm by the fleeces of English sheep." Coarse woollen cloth is another article of export. This trade had extended so much, that in seven towns the London weavers had gilds, and dealers licensed to buy and sell dyed cloth. Little proficiency, however, it is probable, had been made in dyeing, and the red, scarlet, and green cloths in the wardrobe of Henry II. were most likely foreign productions.

After the coming in of the Normans large revenues were drawn from the tin mines, which the Saxons had neglected, and more particularly by Richard, duke of Cornwall, brother of Henry III.; about this time they supplied nearly all Europe; for during the Moorish wars the Spanish mines were shut up, or only partially worked, and those of Misnia and Bohemia, says Camden, had not been opened.

English commerce was now considerable, but in the hands of strangers. "The Pisans," says Matthew Paris, "bring eastern gems, rich silks and purples from Asia, (dyed fine woollen cloths); from Africa, cinnamon and balm; silver from Germany; and Flanders, the weaver of the realm, furnishes rich materials for the garments of the people."

1191. Some small trade was carried on at Bristol, as may be learned from the gild regulation.—"No stranger shall settle in the town, or stay there as a trader more than forty days, nor shall he, while he continues there, buy corn, leather, or wool from another stranger, but only from the burgesses. Nor shall a stranger sell wine but only in his ship, nor cut cloth for sale except at the fair."

Among the inventions and machines of mediæval times those used in war are not the least remarkable. Robert de Brunne says, that Richard I. had in his "barges and galleys mills that were turned by the wind, and by the force of the sails threw fire and stones; the latter of which," he adds, "were had from the Rhine." No machine of this sort is described by military writers.

When the same king was with his fleet off Cyprus, another chronicler relates, that he fell in with and "conquered a mighty argosy," well stored with provisions, arms, and other munitions of war, among which were "abundant phials of Greek fire, and two hundred combustible serpents," or as old Speed reads them, "fireworkes and barrells or cages of venomous serpents." And he tells us that the ship was manned by 1500 Saracens, and that Richard "sacrificed 1300 of the miscreants to Mars and Neptune, and kept the remainder for ransome."

This destructive and dreaded substance was invented about 678, in the time of the Emperor Constantine Barbatus, by Callinicius, an architect, a native of Baalbec. Although in constant use, and often an article of traffic under the Greek emperors, the secret of its composition was carefully concealed, until it was revealed to the Turks, about 904, who thus acquired the same superiority over their enemies the Franks that it had given to the Greeks over them. No other people but the Saracens seem to have subsequently known its preparation, and the secret of its composition has been lost. Anna Comnena says it was made of pitch and other resins mixed with sulphur, and the whole ground together; to this others add oil and wax. Another recipe gives naphtha, sulphur and bitumen. It could only, it was said, be extinguished by human urine, mixed with sand—others said by vinegar; but all agreed water had no power to extinguish its flame. Vessels carrying it were called dromones, and had large tubes of copper and iron erected on their prows, through which the fires were blown into the enemy's ships. The fire could be thrown to a considerable distance. On land soldiers were furnished with copper tubes for a similar purpose, and for their use the fire was made up in a cylindrical form. At times it was put into phials and pots, and fixed on the ends of arrows and bolts, or quarrels. It was poured from large boilers from the walls of a beleaguered city, or it was launched in red-hot balls of iron or stone. Joinville describes it as resembling a long barrel, having a tail the length of a long spear. The noise which it made resembled thunder, and it seemed a great dragon of fire flying through the air, and giving so great a light that he saw in the camp at night as clearly as in broad day.

The combustible serpents found by Richard in the argosy were probably of the kind described by Joinville, and seem to have been a sort of rocket. It has been asked, by what mechanical or chemical means then known could this impulse have been given, combined with these sounds and light, if the opinion that gunpowder was the motive agent be considered untenable?

Richard battered the walls of Acre with round-shaped stones, projected from petraries and mangonels. These were varieties of the same machine. The first was constructed to propel one huge stone with a great velocity, and the other was adapted to scatter many large stones at once.

Bolts or massive darts, or quarrels made of wood headed with iron, were cast as well as stones by the mangonels. Camden says, that "with mangonels, trabaches, and briccolas, they used to cast forth mill-stones." These seem to have been all varieties of the same description of engine—a kind of catapulta of large size. Another machine, applied to a similar use, called the espringold, is unknown. Most of these machines have been minutely described by writers on the tactics of the middle ages. They derived their power from a skilful combination of the resilience of strong springs.

The belfries, or wooden towers, in which the assailants approached the walls, are described to be covered with hides and with *boiled* leather, or leather prepared in some way to render it incombustible. Richard carried one of these wooden castles about with him.

The archibalista, or cross-bow, was much used, if not first introduced into England, by the Normans. Of this there were several varieties. That which projected small stones or metal bullets was called a prodd. The latch was used for darts. In both kinds the bow was bent, and the string hooked by means of a hinged lever. The darts were called quarrels. In sea-fights they were sometimes headed with a combustible substance to set fire to the rigging; at other times they had phials of quicklime attached to them, and were shot into the enemy's ships. The cross-bow never was a favourite arm with the English; the long-bow and arrow continued for ages after this to be their esteemed instrument for inflicting lawful wound and murder. The cross-bow, though a clumsy was a formidable and sure weapon, with the aim at a moderate distance. "Richard I., when standing," says Roger Hoveden, "on the wall of the castle of Chaluz, which he was beleaguering, was observed by Peter Basilij to be within the danger and distance of his steel bow;" making first his prayer to God, "that he would direct that quarrel, with which he had charged his archibalista, and deliver the innocency of the besieged from oppression," Basilij, with a pious deliberation of hand and coolness of purpose, that notwithstanding his impious supplication took from his act even the equivocal plea of *lex talionis*, discharged his latch. The king, hearing the bow go off, and stooping to screen himself, was mortally wounded in the shoulder. "The anguish whereof," says Speed, "was increased by the butcherly and unskilful hand of the surgeon, who having drawn out the wood, and not the envenomed iron, mangled the arm with cruel incisions before he could prevail." Richard, conscience stricken, perhaps, at the many atrocious deeds of a similar kind he had perpetrated himself, without having the excuse of Basilij, forgave the sure-eyed bowman. After the king's death the pardon was disregarded, and Peter was inhumanly flayed alive.

1199. Cloth worked at Nottingham. All persons within ten miles of the town are forbidden to work dyed cloth but in the borough.

Ale was a manufacture in 1216. Henry III. made an assize, by which two gallons of ale in town, and three or four gallons in the country, were to be sold for a penny.

A great advance had been made in ship-building since the time of the Conqueror. Richard I., according to Matthew Paris, had thirteen buccas, or ships, with three sails, all other ships having one only; one hundred ships of burden, besides fifty galleys, each with a triple bank of oars, in the ancient manner. The galleys were of two sorts,—the first, called galiones, used both a sail and rowers, and were larger than the other sort, which were built to be rowed only. These were, however, large enough to carry sixty men, well armed, in iron armour, besides 100 rowers[a].

"In the reign of John, a windmill," says Sumner, "was standing near the nunnery at Canterbury." We have seen they were more ancient, although this notice first distinguishes them in Kent. They had four sails, as at present.

From the manner in which Matthew Paris speaks of glass windows, they were certainly rare, even in churches, in 1217.

1220. The war-horse now covered with plate armour, polished and ornamented.

After the reign of John much cloth came from Flanders, and the export woollen trade seems to have been wholly lost for a time to the English. The trade revived about this period.

A *drawbridge* formed over a creek of the Thames at Queenhithe in 1231. It was a common appendage to the gate of the Anglo-Norman castles.

A *cistern* of *lead* castellated with stone, built by Henry Wales, the mason, in 1235. The lead pipes proceeding from it had a bore of six inches, and were in some cases not bedded in the ground, but enclosed in a large tunnel of brick, into which workmen could descend to repair them.

1234. Painting in oil known. Oil used as a vehicle of colour, when applied to the *lambrusca* or wainscot of wood in the principal apartments of large houses. The queen's chamber in the palace at Westminster was thus painted, as appears by a royal order dated 1234, *pro olio vernice et coloribus emptis*. The wainscoted and the plaistered walls were, however, most commonly worked in distemper, *alla tempera*, or with varnishes made of gluten, or albumen of eggs, and usually in simple colours.

Great quantities of woad imported by Flemish and Norman merchants for the use of dyers, who at this time preferred it to indigò for durability of colour; and in 1236 some merchants of Amiens, Rele, and Corby, purchased permission from the mayor to house this dye stuff in London.

Painting on, or rather staining, glass, is first mentioned in the Close Rolls of King Henry III. in 1236.

Windows are now glazed in some rooms. A precept of the same king, in the 52nd year of his reign, to the Sheriff of Sussex and Surrey, directs that out of the moneys in the sheriff's hands, he was to cause a certain chamber in the Castle of Guildford to be fitted up, among other things, with a wardrobe and necessary closet, and with glazed windows, for his daughter Eleanor.

At this period the Scots made their own flax into linen, and their wool into coarse cloth. Smiths and shoemakers appear in every village, and tanners, dyers, and goldsmiths, in every town. The salt works were objects of great attention, and the right of cutting wood from the forests to carry them on, was often granted by the kings and barons to the monasteries. Judging from the number of malt-kilns and brewhouses in each town, the quantity of ale which was consumed throughout the country must have been very great. Glasgow was noted in this age for its malt-kilns. In a monk's village there were 28 husbandmen, 36 cottages, 1 miller, and 4 brewers. Some villages had a church, most had a mill, but all had their malt-kilns and brewhouses to supply the common beverage. Barley was sometimes malted, but malt was manufactured chiefly from oats. At all the mills great quantities of this corn were ground into meal and malt. Before the age of Alexander II., who died in 1249, windmills had been universally introduced into Scotland; one is mentioned in an old charter at Aberdeen, in 1271, although Anderson and some others say that windmills were invented in 1299. When Edward I. invaded Galloway, the Scots seem to have destroyed them, for the king sent the large quantities of wheat that he purchased to Whitehaven and the ports in Cumberland, to be made into flour and returned to the army.

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[a] Speed says, "Richard had 254 tall ships, and about 60 galliots."—*Historie*, p. 519.

The towns were chiefly peopled by foreigners. The Flemings particularly had extended themselves along the whole eastern coast of Scotland, and had a factory at Berwick-on-Tweed. It is remarkable that in the ancient charters the common people and settlers in the towns are distinguished by the English or Flemish names, and the sirname taken from their trade, as Alan the tanner, and William the smith, at Perth, and Simon the barber, at Berwick; while the inhabitants of the country are distinguished by Gaelic names.

The Scottish exports were chiefly wool, skins, and hides; and they imported wine, spiceries, and corn.

1239. Henry III. granted a charter to the inhabitants of Newcastle to dig for coal, which soon became an article of considerable traffic, and not more than fifteen years after this period it was sent in large quantities to London. A lane, according to Stow, in the suburbs of London, was then called Seacole Lane, because lime was burned there with that sort of fuel.

When Matthias de Besil withdrew into a strong tower in Bristol Castle, it had a triple iron door, and very strong locks, according to Matthew of Westminster.

"Oh, England," says Matthew Paris, "whose ancient glory is renowned among all nations, like the pride of the Chaldeans; the ships of Tarsis could not compare with thy ships; they bring from all quarters of the world the aromatic spices and the most precious things of the universe. The sea is thy wall, and thy ports are as the gates of a strong and well-furnished castle." From this glowing picture, drawn by a cotemporary, and from the history of the imports and naval armaments, it may be gathered that ship-building was carried on to a considerable extent at many places in the island; but at this period we are hardly prepared to seek for a ship-yard at a station so remote as the shore of the Frith of Murray. Yet in 1249, "one of the great ships of the French fleet, a wonderful ship," says Matthew Paris, "was built for the Earl of St. Paul and Blois, at Inverness, near the northern extremity of Scotland." This town, situated at the mouth of some considerable streams which then ran through extensive forests of oak and pine, was probably a convenient place for ship-building, and as every thing is great or little by comparison, even for constructing ships reckoned great in those days. The "large ship" given by the Republic to Formaleone was 125 feet long, and carried 110 men only. It has been observed that the northern shipwrights must have earned a considerable reputation in their craft, before confidence in their skill could have been inspired in distant foreign places[a].

Trade and commerce had enriched all classes in Flanders, when in 1245, the dissensions of the rival sons of the Countess Margaret were permitted by the folly of the people to give the first rude shock to the well-deserved prosperity of their country. In these wicked contests immense numbers of all ranks were sacrificed to decide the absurd pretensions of two profligate and worthless individuals. Thirty thousand men fell in one battle at Walcheren. So great a slaughter produced a stagnation of commerce and manufactures, which depressed for a time the wool-dealers in England, particularly the Cistercian monks, who were the greatest wool-growers in the country, and to whom the Flemings were the best customers; but in the end it was advantageous to the kingdom, for great numbers of peace-loving workmen who abandoned their homes took refuge among us, and assisted to improve the cloth manufacture, that had been established by some of the same race 160 years before.

1247. Henry III. issued a writ authorizing Reyner de Brusell to bring persons from beyond seas skilled in the coinage and exchange of silver, to work at the king's charge. The method of coining in this and bygone times was rude and inartificial. One die was fixed firmly in a wooden block, the other die was held in the hand like a puncheon; the piece of silver of the proper weight was laid on the lower die, and by repeated blows of the hammer on the punching die the required impression was brought up. No further improvement was made on this process for 300 years.

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[a] Inverness appears to have furnished ships to foreigners upwards of 450 years after this period. About 1699 a large ship was built here for the Venetians.

1250. Chain mail, in which the rings of steel are connected, was now in fashion. It cannot be supposed that any specimens of armour existing in our times are of an earlier date than this, for as the cloth or leather decayed, on which the rings or plates were stretched, of the superseded armour it must have fallen to pieces.

The increasing use of expensive foreign silks indicates a better taste, as well as more wealth, in the community. At the marriage, in 1252, of Alexander III. to the daughter of Henry III., a thousand knights appeared in rich silk cointisses, and next day each was arrayed in a new robe of another kind. The Scottishmen are described as being handsomely clothed, but the material of their dress not being specified, it was probably made of the common native material. The finer kinds of linen, also much worn, were procured from Flanders, where it had long been manufactured in great perfection. Of the coarse fabrics, in small quantities, made at home, those of Sussex and Wiltshire were reckoned the best.

The "compassionate invention" of the rowel on spurs is noticed about 1260. The pricker heretofore was a single longish thick sharp-pointed nail, that on most heels must have been a butcherly weapon, and in moments of excitement a deadly one.

In 1261 the woollen trade had spread so widely, and its depression by the civil wars so greatly felt, that its encouragement had become a sort of stepping-stone to political popularity. The barons this year enacted that no wool was henceforth to be exported; it was to be worked into cloth within the kingdom; and to compel every one to wear the home-made fabric that was coarse and ill made, foreign cloth was forbidden to be imported. The leader of the barons considered the country should, and might be, independent of foreign supply, and that the native clothmaker should be encouraged rather than the foreigner. In deference to his plausible temporizing opinion many persons of consideration clothed themselves as the law prescribed. Although erroneous and unjust, it served the state purpose for a season. Some points were overlooked which must be attended to before a law of such a nature can be operative. It was not the *interest* of the *buyer* to wear a coarse home-made cloth, and pay a higher price for it than for a finer imported one; nor was it the interest of the *wool-grower* to take less for his fleece from an English than from a Flemish cloth-maker; nor was it the interest of the *merchant* and *mariner* to shut the import markets against themselves, by losing this medium of exchange; nor, finally, was it the interest of the *cloth manufacturers* to diminish other sources of trade to advance, but fallaciously, their own for a period. The manufactures of salt and iron were rapidly disappearing.

1267. Farriers' shops are described as placed on the roadsides, and made open in front as at present.

It is certain that in the reign of Edward I. there were Greek enamellers in England, who both taught and practised the art. Dugdale describes some enamelled cups existing in his time, apparently of their workmanship.

The master masons of this and following period were chiefly foreigners, incorporated by royal authority. These artisans removed themselves in great numbers to any spot in the kingdom where the foundation of an abbey or other building was meditated; they are not, however, to be considered as the inventors, but rather as the executors of the plans which were prepared for them by the ecclesiastics, who were the only competent architects of the time. The freemasons were blessed by the pope, and were first encouraged in England by Henry III., after which they were constantly employed in the country till the pointed style fell into disuse.

1269. The magnetic needle and azimuth compass described by Peter Adsiger; two inventions which will shortly exert a powerful influence on the arts and commerce of Europe.

Three years afterward, 1272, Roger Bacon described, to those who could decipher it, the composition of gunpowder to be one part, by weight, of sulphur, two parts of charcoal, and six parts of saltpetre, powdered and mixed together. The friar in all probability had found the recipe in a treatise on Pyrotechny written by Marcus Græcus, who, perhaps, copied it from some other author. The most probable opinion is that the compound was known in much earlier times; that it was "invented in India, and brought by the Saracens from Africa to the Europeans," who improved the method of preparing it. It seems to have been first applied merely to recreative fireworks, which will in some degree account for its origin being involved in obscurity. Its properties did not attract notice until it was applied on the great scale to the purposes of war, which may be placed a few years after this period.

Paper, though an ancient manufacture, was not used, though known in England. There is a letter preserved in the Tower, sent by Alonzo, King of Castile, to Edward I., in 1272, which is written on cotton or linen paper.

Passau on the Danube celebrated in this age for its sword cutlery, called "wolf blades." Poitou for lance heads.

1279. John Peckham, an English monk, describes *glass mirrors*, covered on the back with lead, and he observes that no image was reflected when the lead was scraped off. Mirrors of glass were, however, very rare for some centuries after this; they were usually made of polished tin or silver, small in size, fitted into cases, and worn in the pocket.

1280. Raymond Lully was brought into England by Cremer, abbot of Westminster. Lully agreed to make Edward I. rich by his art, if he entered into a war with the Turks. The king did not keep his promise, and Lully, feeling that there were two parties to every bargain, refused to work. The king clapped the artist in the Tower, but Lully was resolute. So strong was popular belief in his skill and art, that the nobles coined by Edward were formed, it was said, of the precious metal made by the magician. This money was first cast from melting pots in long bars, which were cut with shears into square pieces of exact weights, held by tongs, and forged by hammer into a round shape, after which they were blanched, or made white and refulgent, by nealing or boiling, and then stamped with a hammer to make them perfect money. An old rhyme describes the coin,

> "On the king's side was his head and his name written,
> The cross side in what city it was coined and smitten."

The edges of this hammered money were left in a very rude state.

1284. Edward I. received great assistance in his wars from silver mines in Devonshire. In the accounts of William de Wymondham there appears to have been tried and fined at Martinstowe, between the 12th of August and 31st of October, upwards of 370 pounds weight of silver, and next year 521 pounds weight.

Barrington says that a clock was placed, in 1288, in a tower near Westminster Hall, which was paid for out of a fine levied on a chief justice for altering some words in a record. He thinks the clock occupied its original position in the reign of Elizabeth, when, falling into decay, it was removed. Dart quotes an entry made in an old roll of accounts of a sum of £30 paid for making a large new clock for Canterbury Cathedral. Both were, probably, striking clocks, and appear to have been made by Englishmen. At this time clock-making was followed as a craft in Holland.

1296. The miners in Devonshire were either too few in number, or not sufficiently skilful, for this year 337 miners were brought from the wapentake of the Peak, in Derbyshire, to Martinstowe, who fined and cast into bars 704 pounds weight of silver. In the next year, 348 miners, brought from the same place, 25 from Wales, and others natives of the county, were employed, but the quantity of silver raised has not been stated in the accounts. In the next reign silver continued to be brought to the king's monneyers from these mines.

1300. At the commencement of the fourteenth century the manufacturers of Flanders and adjacent districts were in a state of full prosperity. Several causes, however, had been for some time insensibly operating to diminish the profits they had hitherto drawn from some of their manufactures, to reduce the rate of wages, and consequently to abridge the comforts of the workmen. The English, through their proficiency, acquired by the instructions of the Flemings themselves, had succeeded in excluding them as rivals from their home market, in the commoner kinds of fabrics, and were beginning to compete with them for a share of the trade in the same cloths in other markets. The Italians[a], chiefly the Florentines, who had nearly a monopoly of the silk trade, had latterly made such great strides in the manufacture of woollens, that they vied successfully with the Netherlanders, not only in cheaper sorts of cloths, but in the richest and most expensive fabrics.

Under this state of things the Flemish manufacturers began to neglect or omit various regulations which had been framed in other times and state of trade by corporations and halls, in order to preserve what was called the character of the staple, and to prevent deception on their customers. The regulations were found to impose great obstacles to all attempts to supply an altered market with an altered or suitable commodity. The fees and fines, and expense of maintaining these corporation shackles on competition, were heavy, which made their amount be felt, with a lower rate of profit, not only as an injurious but oppressive tax; and the system was now seen to be one which operated practically to compel manufacturers to reside in cities, in order that they might be in the grasp and trammels of monopolizing corporations. The manner in which the hall and corporation funds were managed also entered into their consideration, for in Flanders then, as in England now, the executive officers of the gilds appropriated and disbursed the common funds as if they were solely intended to benefit themselves, or their personal or party connections, instead of being placed in their hands as trustees merely, to be honestly and impartially administered for the good of each member of the incorporated community.

The corporation executive, however, had not only ancient custom in their favour, but the law also in their hands, and they proceeded to enforce obedience to the rights and regulations of the staple, without foreseeing, or perhaps minding, the result. The harsh measures that were resorted to, and which were artfully made subservient to insidious political intrigue, determined large numbers of the manufacturers to withdraw from the jurisdiction of the towns into the villages, and provoked sanguinary riots throughout the country. At Ghent several magistrates and many citizens lost their lives, and at Bruges the commotions were still more disastrous. In May 1301, says Meyer, in his *Annales Flandriæ*, King Philip the Fair, with his queen, made a progress through Flanders, which he alleged had devolved to him as superior lord. They were received everywhere with the most hearty demonstrations of respect, and to do them honour the inhabitants vied with each other in displays of opulence and magnificence. At a public entertainment given by the city of Bruges, the personal splendour of the wives and daughters of the frank and hospitable burghers displeased her Majesty, who exclaimed, 'I thought I was the only queen here, but I see there are many hundreds more.'

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[a] Silkworms in 1304 were reared in vast numbers at Modena, and produced a great revenue to the state. Modenese silk was reckoned the finest in Italy. The Bolognians, however, possessed the machinery for throwing off or twisting the silk, and for upwards of two hundred years the Modenese sent their silk to Bologna to be thrown or twisted. The trade spread from Bologna to other cities, and established itself, among other places, in Lucca, from which some silk weavers emigrated to England. The silk manufacture flourished chiefly at Florence, where it was said, about twenty years after this time, to employ upwards of 16,000 persons.

After the departure of the royal visitors a disturbance arose among the citizens concerning the payment of the public expenses incurred for their entertainment. Many of the burghers, feeling the pressure of the fines and dues by which the money was raised, objected to the extravagant expenditure, which all parties admitted had been "ill bestowed on a selfish, mean-minded woman, who could not perceive the distinction conferred on herself in being a queen of queens, instead of a queen of homely and crouching dependents." Peter King, the deacon of the weavers, with two hundred persons of worship, were hereupon sent to prison, from which they were instantly set free by their resolute townsmen. These trifling circumstances blew the spark into a flame. The real grievance, the grinding corporation imposts, became the bitter topic of discussion and dispute, which terminated in a riot in which fifteen hundred persons lost their lives.

During these disturbances, and at the entrance of the French and Germans into Flanders, numbers of the unfortunate workmen were slaughtered, and crowds of others were driven from the country, many of whom settled in England.

The advantages of this fortunate accession of skilful auxiliaries to English manufactures was, however, for a time thrown away. At the peace made, in 1303, by Edward with Philip, he capriciously banished the Flemish merchants from England, and "thus did as much as lay in his power to ruin the best trade, or rather nearly all the trade of his subjects," in order that Philip should expel from France a few Scottish mercenaries who were in his service.

From the constant accession of immigrant Flemings, the linen manufacture also was rising in importance; in 1307 it had taken root in Norfolk. Aylesham, a small town a few miles from Worstede, had already become noted for its flaxen fabrics[a].

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[a] Fuller gives an amusing account of the means which he supposed were resorted to by Edward to induce the woollen weavers to come over. "Englishmen at this time knew no more what to do with the wool than the sheep that wear it, as to any artificial and curious drapery, their best cloths being no better than

In old records nothing is more common than mention of the "fine cloth of Aylesham," the "Aylesham linens," or the "Aylesham webs."

The diaper, a rich figured cloth of various materials, with a ground of linen, used in surcoats and vestments, sometimes sold as high as four pounds an ell, was a Flemish fabric.

Thomas, Earl of Lancaster, in 1314, according to an account of the expenses of his household quoted by Stow, had "4 clothes ray" in his hall. "Cloth of raye," or striped cloth, was a woollen fabric 6½ quarters broad, rolled or folded single. The entry is thought to be the earliest notice of carpets in England; but this application of the material seems much too early. The floor of the hall at this period, and for centuries afterward, had its appropriate covering of green leaves, straw, or rushes; and it is doubtful if the daïs had any other footing. The "clothes ray" were most probably used as table-covers, which were often of woollen stuff in the times under notice.

It was the practice in 1316 to make wheat into malt. In that year the Londoners forbade the process within the precincts of the city; and the king extended the prohibition to other parts of the kingdom, but the law soon became obsolete. In the Ancient Chronicle of London, the proportions are stated thus:—

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friezes, such their coarseness from want of skill in the making. Unsuspected emissaries were employed by our king in those countries, who wrought themselves into familiarity with such Dutchmen as were absolute masters of their trade, but not masters of themselves, as journeymen and apprentices; these bemoaned the slavishness of these poor servants, whom their masters used rather like heathens than christians, yea, rather like horses than men; early up, and late in bed, and all day hard work, and harder fare, as a few herrings and mouldy cheese, and all to enrich the churles, their masters, without profit to themselves. But O! how happy should they be if they would but come unto England, bringing their mystery with them, which would provide their welcome in all places. Here they should feed on fat beef and mutton, till nothing but their fulness should stint their stomachs. Yea, they should feed on the labours of their own hands, enjoying a proportionable profit of their gains to themselves; their beds should be good, and their bedfellows better, seeing the richest yeomen in England would not disdain to marry their daughters unto them, and such the English beauties that the most envious foreigner could not but commend them. Many Dutch servants left their masters, and brought over their trade and tools, such which could not, as yet, be made in England; and happy the yeoman's house into which one of these Dutchmen did enter, bringing industry and wealth along with him. Such who came in strangers within the doors soon after went out bridegrooms, and returned sons-in-law. Yea, those yeomen in whose houses they harboured soon proceeded gentlemen, gaining great estates to themselves, arms and worship to their families. The king sprinkled them throughout the country, though, generally, when left to themselves, they preferred a maritime habitation." Blomefield says, that it was these Dutchmen who first found out fuller's earth in England, a precious treasure, of which there is more, if not better, than in all the world besides.

"To Brewe Beere.

10 quarters of malte.
2 quarters of wheete.
2 quarters of oates.
40 pounde weighte of hoppys.
To make 60 barellys of sengil beere, the barelle contayning 36 galones."

And this must have been a pleasant, wholesome, and moderately exhilarating beverage.

While the woollen manufacture was spreading on every side, the iron trade was falling into decay. In 1317 this metal was so scarce, that the Scots, in one of their plundering excursions, met with none on which they could lay their hands, until they came to Furnes, in Lancashire, where they seized all the wrought iron they could find, preferring it to any other species of booty. It is difficult to account for this extraordinary circumstance, except from a local scarcity of wood, rendering the iron so high priced as to be beyond the reach of the market. The want of roads and other means of internal communication was more felt in this than in any other description of manufacture. A large wood was soon exhausted, and the deficiency could not be supplied at a reasonable cost from places where the fuel abounded.

1321. Bed-room carpets are mentioned, as being rare. Eleanor, queen of Edward I., had one in her sleeping chamber.

Alchemy was a favourite pursuit, and it would seem that even intelligent persons were impressed with the notion that transmutation was possible. Rymer gives a warrant dated in May 1329, under the hand of Edward III., which says that "The king understanding that John of Rous, and Master William of Dalby, had made silver by the art of alkemoniæ, and thinking if they really possessed such art it would be of great benefit to him and his kingdom, he commanded them forthwith, with all their instruments, to his presence." The king did not observe that all his clothmakers were alchemists, who had found out the secret of transmuting the penny which they gave for the pound of wool into the gold piece which they received for it in cloth.

1329. Blomefield says that he found the woollen trade settled at Worstede, in Norfolk. And the weavers and workers were then enjoined by Parliament to work up their cloths to a better staple than they had done. At the latter end of the reign of Edward III., merchants are noticed as coming to England to purchase them.

1330. Barthold Schwartz, an apothecary, makes known to the Germans the method of preparing gunpowder. Bombards, or cannons, invented about the same time, were at first made of bars of iron, strengthened with hoops of the same metal welded together. They were short pieces with large bores, and in imitation of the tubes with which Greek fire was ejected; they were usually constructed with chambers, which composed the lower half of the cylinder, the upper being open for the admission of the *can* or canister, whence arose the term "cannon." The gun was fixed on a carriage. They were used to throw great balls of lead or stone over the walls of towns to ruin the roofs of houses; and the ranges described curves of little more than 300 yards in radius. Bombards appear to have been used by Edward III. to batter the walls of Stirling Castle. Barber, an old Scottish poet near that period, calls them "crackys of war." Where gunpowder was manufactured at this time does not appear. The bombard used at the siege of Oudenarde, made by the people of Ghent, was 50 feet long, says Froissart, "and threw great heavy stones of wonderful bigness. It might be heard 5 leagues by day, and 10 at night, making so great a noise as if all the devils in hell were abroad."

Milan steel was celebrated for cutlery and armour. Froissart mentions that of Bourdeaux also as excellent for armour; and another says it was equally famed for swords.

1331. The discontents among the Flemings, fomented by Edward and his partisans, occasioning emigration among the workmen, he held out promises of protection to those who settled in England. Rymer has preserved a document in which the king takes John Kempe, together with his apprentices bred to the business, servants, goods, and chattels, upwards of 60 persons, under his protection. These appear to have been fine woollen weavers. Another colony of Walloons came over shortly afterwards, who were followed in succeeding years by many others of their countrymen. Edward strictly prohibited the exportation of wool, and in 1337 he enacted that no cloth made beyond the sea should be brought into England, and that none but English cloth should be worn, except by the king, queen, and other privileged persons; "at the same time, seeing that the industrious Dutch, by their manual labours, grew to so great strength and opulency that their friendship bred rivalry in puissant monarchies, he like a father, regarding the commonweale of his country, proclaimed 'that all cloth-workers of strange lands of whatsoever country they be, which will come into England, Ireland, Wales, and Scotland, within the king's power, shall come safely and surely, and shall be in the king's protection to dwell in the same lands, dwelling where they will, and exercise their trades, and have sundry privileges,' by which invitation," continues Speed, "as very many were drawn, so was it the principal cause of advancing that honest, best, and most beneficial trade in the kingdome, to the great enrichment, strength, and honour thereof." Edward became surety for the immigrants till they could gain by their occupation.

While the king was thus employed, laudably so far, in peopling towns and villages with ingenious and industrious workmen, the magistrates of Bristol were busied in thwarting them. In 1342 they persecuted with exactions Thomas Blanket, and some other citizens, who taking advantage of the influx of the immigrant Flemings, had set up looms in their own houses, and hired weavers and other workmen, to commence making woollen cloth. Blanket appealed to the king. In the king's letter to the corporation he says, "considering that the manufactures may turn out to the great advantage of us and all the people of our kingdom, you (the mayor) are to permit the machines to be erected in their houses at their choice, without making, on that account, any reproach, hindrance, or undue exaction." This mandate put a stop to the rapacity of the corporation[a].

1347. Cannon, says Camden, were used by Edward III. at the siege of Calais. After he entered Caen, the Frenchmen retreated to their houses, and cast down great stones, timber, hot water, and bars of iron, and slew 500 persons.

Edward had long been endeavouring to form a party in Flanders, or as Speed says, to "unite unto him the High and Low Dutch princes and people, which lay most confederate for his uses." He also sought the amity of Lewis of Bavaria, with whom he made, as by the event was manifest, an unprofitable confederation, though for the present it seemed to serve his purposes. "More to his advantage were the singular endeavours of some of his other private instruments, as chiefly of Jacques de Artevile, (a great brewer and wealthy burgher of Ghent,) one of a rare dexteritie of wit, and so popularly acceptable among the Flemings that he seemed to sway Flanders more by far than the earle thereof whom they had expelled. By the special diligence of this Jacques, and of one Signor de Courtray, a nobleman of Flanders, there was prepared among the artisans of those parts, whose chief enrichments depended on the handling of English wool, as cloth workers, weavers, and the like, a mightie party for the English against the French. Meanwhile King Edward, the life of this high affair, proceeded in all things with due deliberation and judgment; therefore, to let the Flemings know the want of his friendship, he had for some years before inhibited the transportation of *his* wools, which, and for that the English were in a manner become all one with them by King Edward's marriage with the Lady Philippa, not a little advanced the practice of Jacques on his behalf, which was sped at last by an overthrow given in the isle of Cadsand, to the French, under the conduct of Guy, the bastard of Flanders by the Earle of Derby, of the fame and fortune whereof the said D'Artevile and others of the king's friends made so wise and seasonable use by letting them see the English were able to protect them, that the Flemings without any great stay became his firm confederates." The upshot of these wicked and hollow intrigues was calamitous.

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[a] In 1340, according to the calculation of Villani, upwards of 30,000 persons were employed in the woollen manufactures of Florence.

He seems to have given his name to a well-known variety of woollen fabric. In an old chronicle, thought to be written temp. Ed. I., "blankettes of fussyane" are mentioned, but the age of the chronicle is very doubtful, and the use of this word so early will not, perhaps, increase the certainty of the date assigned to its composition.

In 1348 a great "movement" having been excited among the clothworkers, horrible barbarities were inflicted upon them. Six hundred were slain in one skirmish; and Meyer says, that those who remained at home were dragged out of their houses and mutilated and murdered. They deserted their abused and desecrated country in crowds, and scattered themselves in the adjoining provinces and in England. Artevile, who had become the popular tribune in Flanders, was the constant partisan of Edward. After this demagogue, who drew great misfortunes on his countrymen, was slain in a tumult at Ghent, Edward's interest declined. His friends, the unfortunate dupes of his flagitious "policy," were banished, and the protection he gave the beggared and expatriated Flemings was an invitation, in 1351, to settle in England, which was repeated next year with a grant of some trifling privileges to the manufacturers of cloth, who continued to come over to avoid persecution at home.

1352. The king grants authority by letters patent to Henry de Brusell and John de Cicestre to choose and take as many goldsmiths, smiths, and other workmen, as they required, in the city of London, and place them at work in the tower, at wages to be allowed by the patentees. If any of the pressed mechanics should refuse to work and be rebellious or run away, they were to be seized and put in prison until the king, Edward III., should determine on their punishment.

The stuffs used for men's dresses seemed to have been printed or embroidered. "Att that tyme the Englishe men were clothede all in cootes and hodes peynted with lettres and with floures," says an old chronicle.

1354. No iron manufactured in England. Parliament, to prevent its rising in price, enacted that none wrought or unwrought should be exported under heavy penalties, and the dealers were subjected to the inspection of the justices. During this and the succeeding century the market was supplied from Germany and Spain.

1360. While Edward was encouraging manufactures with one hand, he was depressing them with the other; in this year he ordained that ornaments of gold or silver, or daggers, girdles, necklaces, rings, or other ornaments for the body, should not be worn by any one who had less than 10*l.* a year; nor any fur by those who had not 100*l.* a year.

A woollen stuff called sayes, manufactured in Ireland in considerable quantities, was so much admired in Spain, that it was imitated by the manufacturers of Catalonia. It was equally esteemed in Italy, and worn in particular by the ladies of Florence, at a time when that city abounded in the richest and most exquisite manufactures, and where the luxury of dress was carried to the most gorgeous extreme. It is certain from this notice that many Flemings had crossed the Irish sea.

Three clock makers, John Uninam, William Uninam, and John Latuyt, were, in 1638, invited from Delft by Edward III. to settle in England. Barrington thinks it probable that there were clock makers, or persons who at least pretended to understand clock making, in England, for the royal protection given to the three Dutchmen directs that the artists to whom it is granted shall not be molested while they are engaged in this employment.

1369. To the skill and invention of John Kempe, and the host of ingenious Flemings of the same and auxiliary trades who followed them to England, we are indebted for having established the manufacture of fine woollen cloth on a foundation that has not once been shaken for five hundred years. But neither their skill, nor their habits of industry, nor the knowledge they had spread of a valuable manufacture, nor their misfortunes, could save them from the persecution of the native cloth makers and weavers, who were become skilful, and were growing rich, from following their examples and instructions. These meritorious Flemings were at all times the objects of vulgar hatred and malice, and their lives in danger. In the summer of 1369, more particularly, they became the victims of popular fury; and gross outrages were committed upon them, until Edward issued a proclamation declaring them to be under his especial protection. A short time after his death, the ill will of the native workmen again broke out into open violence against the "cursede forrainers." Richard II. acted as a mediator, and an agreement in 1379 was effected between the native and foreign interests, which was confirmed by the royal authority.

The foreign workmen were now so numerous in London, that places were assigned to them in which they could deliberate on the affairs of their communities. The churchyard of St. Lawrence Pulteney was appropriated to the Flemings, and that of St. Mary Somerset to the Hollanders.

1370. During the two preceding reigns there are no vestiges of the art of painting, although it certainly was preserved among us, at least by painting on glass. "And there is," says Walpole, "little wonder that a proud, and warlike, and ignorant nobility, encouraged only that branch which attested their dignity—their dungeons were rendered still darker by their pride." It was the case with all the arts; none flourished but what contributed to display their wealth, or contributed to their security. They were magnificent without luxury, and pompous without elegance. Rich plate, even to the enamelling on gold, rich stuffs, and curious armour, were carried to excess; while their chairs were pedestals, their tables as clumsy, their clothes were incumbrances, and they knew no use of steel but as it served for safety or destruction. Their houses, for there was no medium between them and hovels, implied the dangers of society, not the sweets of it. Whenever peace left them to think of modes, they seemed to imagine that fashion consisted in transfiguring the human body instead of adding grace to it.

"After the battle of Cresci," says Warton, "and towards the end of the fourteenth century, riches and plenty, the effects of conquest, peace, and prosperity, were spread on every side, and new luxuries were imported in great abundance from the conquered countries. There were few families, even of moderate condition, but had in their possession precious articles of dress, furniture, such as silks, furs, tapestry, embroidered beds, embossed cups of gold and silver, agate and crystal bracelets, chains and necklaces, brought from Caen, Limoges, and other foreign places."

Dean Prideaux says that he saw a representation on paper of some acts of John Cranden, Prior of Ely, which bears date 14 Edward II., 1302; and that, in the Bishop's Registry, at Norwich, there is a register book of wills, all made of paper, which bears date as high as 1370, which is 100 years before its use was known in Germany, according to Mr. Ray.

The art of making paper with linen rags is supposed to have been discovered in the eleventh century; Mabillon thinks in the twelfth century; but Montfaucon was not able to meet with a single leaf of paper of an earlier date than 1270, about the death of St. Louis.

1373. The ships in the fleet of Edward III. in 1373 were of small size. Not more than two or three were of so great burden as 200 tons, most of them from 40 to 100 tons. Among them were many Spanish, Portuguese, and Genoese craft, hired by the king.

1377. The French, who intended to invade England, covered the masts of their ships with leaf gold. "Lord Guy, of Tremoyll, so garnished his ship that the gilding cost him *222l.* of the current money of England."

Two of these French ships brought into Sandwich Haven as prizes, had on board "a part of a huge strong timber wall that King Charles caused to be built, in length 3 miles, in height 20 foot, which had at every twelve paces a tower ten foot higher, and each capable of 10 men, the whole to be a defence for the French encampment against our shot and a shelter for theirs." There was also, says Speed, in the same ships, "the engineer and master workman, who was an Englishman."

Richard II. was fond of fine clothes, he had one coat of gold and precious stones which cost 31,000 marks.

Richard II. directs Thomas Norbury to buy of Thomas Relswold, of London, two great and two less engines called cannons, and 600 *stone shot* to be sent to the castle of Brest. In the same year, John Bucq, the French admiral, was, says Froissart, in a "ship with three cannon which cast forth darts." These darts were so large and heavy that they did much damage[a]. Bucq was captured.

A tower running upon wheels was used by the English at the siege of Reole. The soldiers moved it wherever they desired. It could contain, Froissart says, one hundred knights and one hundred archers, who annoyed the besieged with their arrows, and was covered over with boiled leather to prevent its being set on fire.

The art of founding brass or copper, and also of casing and plating with them, had been long previously to this carried to great perfection. Several specimens are still extant, and the faces are portraits of the persons commemorated. 1246: Statue of Aylmer de Valence, of oak, plated with copper. 1272: A statue of Henry III., in copper gilt. 1290: A statue of Queen Eleanor. 1307: A figure of Edward I., copper gilt. 1377: A statue of Edward III., copper and gilt. The existing contracts are all made with English artists, coppersmiths, chasers, and gilders.

1381. Richard II. appoints a die-sinker to the mint; previous to this the office had been hereditary in the family of Otto, the goldsmith, who held it from the Conqueror. The high rank of some of those persons who filled the office almost forbids the supposition that they could be the makers and formers of the dies, yet they are stated to be so in the reign of Henry I., and as late as 1354. Fifty years after this date, the "sculptor of the dies of gold and silver" was allowed a house and a stipend of twenty pounds a-year. The "moneyers" were not magnates, but of the middle class, who had workmen under them, and probably operated themselves.

The French threw "Greek fire" on the English at the siege of Barbourgh, perhaps in imitation of the real fire; unless the compound was procured in traffic from the Saracens.

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[a] Some bombards were made to propel shot of extraordinary weight. The renowned Peter Doria had his brains knocked out by a stone bullet which weighed 195 lbs., shot from a bombard called Trevesian.

The art of gilding metals followed as a trade. Embossing and chasing practised by natives; and also the delicate art of enamelling on gold.

Richard II. enacted that none of the king's subjects should carry forth or bring in merchandise, but only in ships of the king's allegiance. Some ascribe a wise, far-seeing policy to this measure, and date from it the rise of the maritime greatness of England. Others view it as prompted by a false and narrow policy, which was now followed in every thing; and that it had no higher aim than to be an extension of the corporation regulations to shipping. That there was as little foresight as either wisdom or humanity in the legislators of this age, is apparent from the act of 1388, by which it was enacted that "no artificer, labourer, servant or victualler, shall depart from one hundred to another without license under the king's seal."

1382. Much cloth of various colours exported to Italy, among which is particularized "green tapestry powdered with roses."

Froissart presented Richard II. with a book "On Love," handsomely written and illuminated, *bound* in crimson velvet, with ten silver gilt studs and roses of the same on the middle, with two large clasps of silver gilt, richly worked with roses in the centre.

1386. Leland states that Richard de Walingford, abbot of St. Alban's, made a clock which represented the revolutions of the sun and moon, the fixed stars, the ebbing and flowing of the sea, and many other lines and figures, and was altogether, in Leland's opinion, not only the most wonderful clock ever seen in England, but in Europe. It was called Albion by its maker. The abbot was the son of a smith, who lived at Walingford. His clock continued to go for upwards of 250 years.

Chaucer mentions clocks as if they were not uncommon. To show the certainty of a cock's crowing, he says:

> "Full sickerer was his crowing in his loge,
> As is a clock or any abbey orloge."

Gunpowder at this time does not appear to have been made in England.

Anne, princess of Bohemia, queen of Richard II., introduced the custom of ladies riding sidewise. The side saddle was of course a German article. The Saxon ladies rode sidewise on a sort of pillion, but the method it would seem had grown out of fashion, and the Anglo-Norman horsewomen preferred sitting astride.

Among the petitions to Richard II. in this year are those from cordwainers, founders, armourers, blacksmiths, pinners, spurriers, saddlers, and embroiderers.

1389. The arts of trade have at all times much the same object. Complaint is made to Parliament, (13 Rich. II.,) that in the counties of Somerset, Dorset, Bristol, and Gloucester, wherein much broad cloth is made, it is sold tied up and rolled, having those parts which are outside and visible fair and well made, but the inside often torn, ill made, and of a bad colour, not agreeing with the outside; so that the merchants who buy the cloth and carry it out of the realm to sell it to foreigners are often in danger of being put to death, and are sometimes imprisoned and put to fine and ransom, and their cloth burnt or forfeited when it is untied or opened, to the great scandal of the kingdom; in future pieces were not to be tied or rolled up, but brought to market open.

A company in London for the manufacture of linen.

1395. Paid 400*l.* to Nicholas Broker and Godfrey Prest, for a statue of the king (Richard II.) and one of the queen, made of copper and gilt, with their crowns on their heads and their right hands joined. This entry gives a very favourable notion of the skill of the founders at this period.

Pins were a home manufacture, but *needles* were had from abroad. They were sometimes used as ornaments. When the Prince of Wales, afterwards Henry V., went to make peace with his father, "he was apparelled in a gown of bleu satten full of small oylete holes, and at every hole the needle hanging by a silke threade with which it was worked."

1399. Embalming now does not mean "salting." "When King Henry wist that King Richard was cldede, he lettes ere him in the best maner, and closede hym in a fayre chest with divers spices and baumes, and closede hym in a linnen clothe saue hys visage."

1404. Henry ordained "that none from henceforth shall use to multiply gold or silver, nor use the craft of multiplication under the pain of felony.

Gilding and silvering the common metals to deceive the ignorant, so prevalent that Parliament this year, 1403, enacted, that no artificer shall gild or silver any locks, rings, beads, candlesticks, harness of girdles, chalices, hilts nor pommels of swords, powder-boxes, nor covers for cups, made of copper or latten, unless at some part of the article the copper or latten be left bare to prevent fraud. Embroiderers having also used copperfoil gilt for gold thread are brought under the law.

Henry IV. complains of the fletchers, or arrow-smiths, and directs that the heads of arrows should be well boiled and brazed, and hardened at the point with steel, with the maker's name to them.

The will of William of Wykeham leaves no doubt that the arts of enamelling, limning, and embroidery, which were borrowed from the French, were practised by numbers, and carried to considerable perfection, at the commencement of the fifteenth century.

1406. Wars and pestilence had so thinned the people that the land lay uncultivated through a want of labourers. The landholders being the law-makers, enacted "that whoever had been employed at the plough or cart until he was twelve years of age, should be compelled to continue in that employment during life; and none who had not lands or rents to the value of twenty shillings a year (about ten pounds at present) should be permitted to apprentice their sons to any trade, but should bring them up to husbandry."

1408. Darts, or quarrels, shot from cannon. "The Earle of Kent was smote on the heade by a quarell from one, and died."

1412. Gunpowder is now manufactured in England; this year its exportation was prohibited. A licence is granted to the ambassadors of the Earl of Alençon to carry home with them 400 lbs. of saltpetre and 100 lbs. of sulphur. These seem also to have been forbidden articles. Gunpowder when first made was not corned or granulated, but used in its mealed state, and was then called "serpentine powder."

1414. Lanthorns hung out by the citizens of London, opposite their houses, to light the streets.

At the battle of Agincourt, 1415, Henry had cannon, which he planted on an eminence. The French within their lines had *saximova* (mangonels or bombards?) Elmham says, that when the English army, commanded by the Duke of Gloucester, besieged Cherbourg in 1418, the besieged discharged *red hot balls* of iron, to burn the huts in which the English soldiers were lodged; yet Polydore Virgil says, that the French hardly knew the use of cannon in 1425.

At Agincourt, the bridle and furniture of Henry's horse was, says Speed, of "goldsmith's worke."

In military operations mining and countermining were practised. They dug under the walls and supported the ceilings of the galleries on posts, which were set fire to when the mine was completed: when burnt, the walls fell down.

The two-handed sword introduced by the bladesmiths about 1425.

Though tin and lead had been wrought in England from early times, the English miners were not considered so skilful as those of some other countries, where the art had not been so long practised. Henry VI. having failed in his attempts to procure gold and silver by the art philosophical, brought over, in 1430, Michael Gosselyn, George Harbryke, and Matthew Laweston, three famous miners, with thirty other miners in their company, from Bohemia and Hungary, to superintend and work the royal tin mines, and instruct the Cornwall men in their art.

The price of salt was high, and the supply fluctuating, from the produce of the mines and pits being inadequate to supply the consumption, and sea-salt making was imperfectly understood. Henry VI., learning that a new and better method of making salt had been invented in the Low Countries, invited, 1438, John de Shiedame, a gentleman of Zealand, with 60 persons in his company, to England to instruct his subjects, and gave them his protection and encouragement.

1415. In the order for the pageants of the play of Corpus Christi during the mayoralty of William Alne, the following crafts and callings were marshalled at York:—tanners, plasterers, carde makers, fullers, coupers, armourers, gaunters, shipwrights, fishmongers, mariners, pthemyners, bukbyders, hosyers, spicers, pewterers, founders, tylers, chaundelers, goldsmiths, gold beaters, mone makers, masons, marashals, girdelers, naylers, sawters, sporriers, lorymers, barbers, vyntners, smiths, aulnnayers, plummers, patten makers, pouch makers, botilers, cap makers, vestment makers, skynners, cuttelars, bladesmiths, shethers, scalers, buklemakers, horners, bakers, waterleders, sautmakers, milners, tiel makers, ropers, ewers, turners, heyresters, bollers, shermen, pynners, lateners, payntors, bouchers, pulterers, satelers, glaziers, carpenters, joiners, cartwrights, carvers, sawyers, wyredrawers, broggers, wool pakkers, wadmen, escriveners, lumners, questers, dubbors, tailyeurs, potters, drapers, lynwevers, wevers of wollen, mercers, hostilers.

1419. Cannon balls made of stone. Henry V. commissioned John Louth, clerk of the ordnance, and John Rennet, mason, in Maidstone, to make 7000 cannon balls from quarries on Maidstone Heath. Twelve great carriages were to be provided for the land guns, and twenty pipes of powder made with charcoal of *willows.*

The use these balls were put to is given in an old chronicle:—"Henry V. receyued a tauntyne message frome the dolfin of Fraunce, and a tonne of tennes balles (in derision). Hee anoone lette make the tennes balles for the dolfin to playe withalle. He playede att the tennes withe his harde gonnestones that were shott into the towne, and whenne they beganne to playe, they withinne the towne sange well awaye, and sayde allas thatt evir suche tennes balles were made, and cursede all those thatt the warre beganne, and the tyme thatt they evir were borne."

What material the gonnes were made off is not certain. Caxton, in 1486, speaks of "a grete gonne of bras, and manie othere grete gonnes and serpentyns." Balls of lead and iron were used and "erthe balls," probably baked clay balls.

The hand-guns, or hand-cannon, which were used at the siege of Lucca, in 1430, and which were soon after this introduced into England, are described by Billius, a noble Milanese. "The Milanese, besides darts, and what projected arrows, invented a new kind of weapon; also in their hands they held a sort of club about 1½ cubits long; to this were affixed iron tubes, which being filled with sulphur and nitre, emitted iron balls. The blow, if it struck, was certain destruction; neither armour nor shield were sufficient protection, for often two or three deep, if fired upon, would be transfixed by a single ball."

For two hundred years after the invention of gunpowder all fire-arms were called cannon.

King Henry's body was embalmed, wrapped in cerecloths, and enclosed in a *leaden* coffin.

When Henry V. went to France, "he stored himself with all manner of ordnance, armoure, gonnes (cannon), tripgettes (engines for throwing stones), engines (mangonels?), scales (ladders), bastells (wooden towers), brugges of leather (small boats), pavisses (large shields), bows and arrowes, and a shippe with a gonnes and gonnepowder."

The Normans in Caen threw from their walls, perhaps with mangonels, "grete barres of yron, hot pitche, brennynge brymstone, and boylynge leade." On the side of the English, says Grafton, "some shot arrows, some set scaling ladders to the walls, others shot gonnes, some broke the walls with engines, and others cast wildfire, every man endeavouring to come hand to hand with his enemies."

Caen was strongly fortified. On the top of the embattlements, says Grafton, there were "great rolls of timber, so moving and so unsteadfast, that neither any scaling ladder could catch any hold, nor no person that would climb up could get any sure footing."

1430. A manufactory of linen established in Ireland.

1444. JOHN COBBE, in a petition to Henry VI., states that he was desirous of operating upon certain material, by the "art philosophical," namely, to transmute the inferior metals into perfect gold and silver. The king, who felt that no harm could come to any one, and much good might arise, even to himself, if Cobbe succeeded, granted his licence to practise his art, notwithstanding the law made by Edward IV. against it.

1450. Alum, a costly article, in great demand, was procured mostly from the Genoese, who had farmed some alum works from the Turks, near Smyrna. Henry VI., after trying many ways to make money, besides that of alchemy, in this year turned the penny by an adventure in alum. He purchased a quantity, for which he gave £4,000, and resold it to some merchants for £8,000, and by this means put a sum equal to £34,000 of our present money in his pocket. The merchants, nevertheless, made a profitable bargain, for kings do business at most times out of the common manner. Henry issued a proclamation, which was probably part of the agreement, prohibiting the importation of alum for two years; during which time all the dyers in the kingdom were at the mercy of the speculators[a].

1455. The art of spinning and throwing silk had been introduced by a company of silk women, of what country is not known. These females, in a petition to Parliament, stated that Lombards and other Italians imported such quantities of threads and ribbands, and other silk things, that they were impoverished. To protect *them* an act was passed prohibiting the importation of the articles which they fabricated.

Several kinds of projectiles such as cannons, culverins, made by natives; probably of iron only.

1456. Patent granted, with authority of Parliament, to JOHN FACEBY and others, to make that most precious medicine called the "fifth essence," and the philosopher's stone," and to practise the transmutation of metals into true gold and silver." This record speaks in the highest terms not only of the transmutation of metals but also of the elixir, by which all curable disorders would be healed, human life prolonged to its natural term, and man preserved in natural health of body and mind.

1457. Henry VI., who was generally in great want of money, appointed a commission to inquire into the truth of the art of converting the "base metals" into the noble metals, by the professors of which he had been promised wealth sufficient to pay all his debts in gold and silver, to the great advantage of the kingdom and ease of himself. The commissioners were Augustine and preaching friars, the queen's physician, the master of London College, an alderman, a fishmonger, two grocers, and two mercers; their report was favourable, and another license to practise it was issued shortly afterwards. The possibility of the art does not seem to have been doubted.

1461. The manufacture of beer for sale now regulated by the king, who appointed surveyors, as John Devinish and another, to superintend the brewers, and ensure a wholesome beverage to the public. It had from the Anglo-Saxon period been an unfettered traffic.

Some soldiers provided with hand-guns. These tubes were bound round at different distances of their length, being probably composed of two or more pieces thus held together. Matchlock invented; suggested by trigger of cross-bow.

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[a] The cloth made in Italy in 1450 was sent to Constantinople to be dyed, on account of the abundance of alum in that neighbourhood. At this time 300,000 pieces of gold were paid to the Turks for this article. In 1458 alum was discovered and made at Volterra, and by John de Castro in the papal territorics in 1468. The popes managed to get the whole of the alum trade of Europe into their hands.

Some hand-guns, or hange guns, a simple barrel, furnished with trunnions, and hung like a cannon, on wood, by which it was held in the hand.

Platters, basins, dishes, and jugs, generally made of wood; spoons of the same material, or of horn, and the drinking cup of the same material.

A list of the articles which Edward IV. prohibited, in 1463, being brought into the country. Woollen caps, woollen cloths, laces, corses, ribbands, fringes of silk and of thread, laces of thread, silk twined, silk any way embroidered, laces of gold, of silk or gold, saddles, stirrups, or any harnesses pertaining to saddles, spurs, bosses of bridles, aundirons, gridirons, any manner of locks, hammers, pinsons, fire-tongs, dripping-pans, dice, tennis-balls, points, purses, gloves, girdles, harness for girdles of iron, latten steel, tin or of alkemine; any thing wrought of any tawed leather, any tawed furs, buscans, shoes, galoches or corks, knives, daggers, wood-knives, bodkins, sheers for tailors, scissars, razors, sheaths, playing-cards, pins, pattens, pack-needles, any painted ware, forcers, caskets, rings of copper or of latten gilt, chaffing-dishes, hanging candlesticks, chaffings, balls, sacring-bells, rings for curtains, ladles, scummers, counterfeit basins, ewers, hats, brushes, cards for wool, blanch-iron thread, called white wire.

This comprehensive catalogue perhaps includes most of the articles fabricated at this time in England, and many of which had hitherto been imported. From unwrought iron not being in the list, the low state of the iron manufacture may be inferred. At this time it seems to have been had from Spain.

1461. Holland linen commonly used for shirts by the rich. Much of the finest sort came from Rheims.

1464. "Patten makers," says the act, "may make pattens of such ash as is not fit for shafts." An enactment which discloses the general scarcity of wood throughout the country.

Powle davies. No weaver or other person to offer to sale any of the said cloths before the stuff be well beaten, scowered, bleached, and the cloth well driven with a brazen or iron shuttle.

1467. No lamb's wool to be woven in the following sorts of cloth:—Beds, monks-cloth, channon cloth, double motleys, single motleys, double worsted, half double worsted and roll of worsted.

1468. The law had taken no notice of the alchemists until now, when one Eden confessed himself guilty of "multiplication," that is, making the "fifth essence" and the philosopher's stone, whereby all metals may be made gold and silver. He also accused one Whalley, at that moment a prisoner in the Tower on another charge, "that he did move and practise the art, and had employed money for red wine and other things necessary to be prepared for the operation. The offence was felony, but Eden, as a principal, came under a general pardon that had been issued by Edward IV.; Whalley, being an accessory and in custody, was excepted from it.

1472. Art of printing and manufacture of books introduced into England by William Caxton.

1473. Cloths of gold and silver manufactured in London.

1475. About this time the harquebus invented; Latin word arcus busus, evidently derived from the Italian *arca bouza*, a bow with a tube or hole. To that people we are to attribute the application of the stock and trigger. Hitherto the match had been applied by hand to the touch-hole; but the trigger of the arbalest suggested the idea of one to catch into a cock, which, having a slit in it, might hold a match, and by the motion of the trigger be brought down on a pan which held the priming. The touch-hole being thus no longer at the top but at the side.

The manner in which tiles were made according to the act of 1477, is as follows:—The earth was to be dug before the first of November, which was to be stirred and burned before the first of February; and then the same digging and casting up, but not to be wrought before the first day of March. And before the prepared clay was put up to make tile, it was to be truly wrought and freed from stones. The veins of earth called malms or marl and chalk, to be taken out of the land, if it contained them, before the tiles were made.

1476. The manufacture of bread has at all times been an especial care of governors, local and general; and in all times bakers have been considered, perhaps erroneously, as less scrupulous to deceive than other tradesmen. Those at Coventry seem to have been worse even than their neighbours. In this year, according to the historian, Symonds, the mayor, administered to the dough working craft "sharp correction for light bread." The dealers were thus made more honest for a time; but in 1483 bad practices had been so general that all the bakers in Coventry fled to Bagginton Castle, and took sanctuary there on the morrow of Candlemas to escape from the popular fury.

1478. The art of making gold by an occult process still cherished at court. Edward IV. grants a licence to John Frensh "to practise a true and p'fitable conclusion in the cunnynge of transmutac'on of metails to our pr'fyte and pleaseire."

1481. Edward IV. gave a commission to William Temple to press masons, smiths, and plumbers, to make balls of stone, iron, and lead.

1483. Dyers began to use orchell and corke, brought from beyond seas, called "jarecork." These articles are prohibited by parliament, because "the colours made with which been so deseyvable that the same colours may in now way abide."

"Previously," says another act, made this year, "many honest persons get their living by fulling hats and caps with their 'mains et pees.' Now they begin to be thickened at fulling-mills, which practice is prohibited."

No ribbands, laces, corses, girdles, callez-silk or collein-silk shall be imported "to impoverish the country."

After this period the woollen fabrics were not only produced in sufficient quantity to supply the demand at home, but also to provide a large amount for exportation.

Finers and parters (assayers) of gold and silver, a craft.

Ploughs now have a coulter and wheels, and two handles; for centuries before this the farmers had harrows, rollers, forks, scythes, sickles, rakes, carts and waggons, the same as at the present time.

To the articles prohibited by Edward IV., the following were added by Richard III. in 1483: Cobbards, stock-locks, keys, hinges and cornets, painted glasses, painted papers, painted forcers, painted images, painted cloths, beaten gold, or beaten silver wrought in paper for painters, saddles, saddle-trees, chains, latten nails with iron shank-handles, funnels, hanging-candlesticks, bells, (except hawk's bells,) tin and leaden spoons, grates, horns for lanterns.

Bow staves had become very scarce, and had risen greatly in price. The act passed by Richard, says "it is owing to the seditious confederacy of the Lombards that bow staves be now at such outrageous price of 8 pounds the hundred, where they were wont to be sold at 40 shillings; and that they (Lombards) will not suffer any garbling (selection) out of them, but sell good and evil together at such an excessive price, that this realm is like to fail as well of stuff of artillery as of workmen thereof;" and therefore the act directed that every merchant of Venice, and others, was to import 10 bow staves, good and able stuff, with every butt of Malmsey or Tyre wine; and the staves were to be sold only to persons under the king's allegiance.

Richard enacted that no foreign artificer, or merchant, scrivenor, alluminator, reader or printer of any book, was to be hindered from importing or retailing such book, or from living in the country to follow his occupations.

The art of engraving was practised almost as soon as that of printing. Caxton's Golden Legend has in the beginning a group of saints, and many other cuts dispersed through the body of the work.

1484. An Act of this date states that the number of artificers and other persons not born under the king's obeisance who daily resort to London, and other towns, was much greater than in times past it was wont to be. These strangers also inhabit by themselves with their wives, children, and households, and will not take upon them any laborious occupation, as going to plough and cart, and other like business, but use the making of cloth and other handicrafts, and carry from the parts beyond seas great substance of wares and merchandize to fairs and markets, to the impoverishment of the king's subjects, and will only take into their service people born in their own countries, whereby the king's subjects, for lack of occupation, fall into idleness and vicious living, to the great perturbance of the realm.

1485. A century before this date plasterers were called dawbers and mud-wall makers, who had for their wages, by the day, three pence, and for their knave three halfpence; they so continued until Henry VII. brought into England, with him, out of France, certain men that used plaister of Paris about the ceilings and walls of his palaces, whose statute labourers these dawbers were. These statute labourers learned in a short time the use of plaister of Paris, and did it for the king, and increased to be many; then suing to him for his favour, the king fulfilled their desire, and incorporated them by the name of *Gypsarium*—which was for "clay and mud, alias mortar makers." In the next reign they called themselves "plaisterers, alias mortar makers, for the use of loam and lyme." But for half a century, the public, who would not sanction the innovation, called them "dawbers."

The great desire to improve English manufactures by inviting and encouraging foreign workmen to settle in England in previous reigns, is strangely contrasted with the policy of Richard against immigrants. By law "no stranger of any country durst board or lodge any other stranger not of the same nation with himself"—nor durst any foreign merchants "host with any other foreigner of a different country than his own," under a penalty of £40.

1486. Foreign merchants and victuallers are commanded, by an act passed this year, to lay out *all* the money they receive for their wares in purchasing the merchandise and commodities of this kingdom only, so that no gold or silver shall be carried out of the country.

Another act orders no cloth to be transported, except it is barbed, rowed, and shorn, whereby the "poor commons or the crafts of shearmen, fullers, and other artificers, should live and obtain their needy sustentation, by means of drapery made and draped within the realm, but which was daily sent unshorn, whereby outlandish nations with the same drapery are set in labour and occupation, to their great enriching, while the poor commons, the king's true liegemen, that of natural reason should obtain their needy sustentation by means of the same drapery, for lack of such occupation daily fall in great numbers into idleness and poverty, to their utter destruction."

In London the mayor and citizens made a regulation that no freeman of the city should go to any fair or market out of the city, with any manner of ware or merchandise to sell or barter. This extraordinary ordinance, which carried gild exclusion farther than it had ever been carried before, excited the hostility of other corporations; and an act was passed by Henry VII. annulling the city law, because, says its preamble, "it would be the destruction of all other fairs in Salisbury, Bristol, London, Oxenforth, Cambridge, Nottingham, Ely, Coventry, and in many other places where the lords spiritual and temporal, abbots, priors, knights, esquires, and the poor commons, resort to buy and purvey things good and profitable." Bacon observes that it was the endeavour and policy of Henry VII., throughout his reign, to repress and keep within reasonable bounds the bye-laws of corporations, which, under his predecessors, had become universal practical despotisms.

Henry observing that, from the unsettled state of the country under his immediate predecessors, the woollen manufacture had become languid and was declining, he drew over a great number of the best cloth workers from the Netherlands, which gave a new vigour to cloth-making operations.

1487. A broad yard of the finest scarlet grained, or other grained cloth of the finest making, was not, by law, to be sold by retail for more than 16 shillings a yard; nor a broad yard of any other coloured cloth to be sold for more than 11 shillings a yard, under a penalty of 40 shillings. Nor was any hat to be sold for more than 20 pence, nor cap for more than 32 pence, under the same penalty. Wine and woad could only be imported and exported in English ships and by Englishmen.

1490. Standard weights and measures made of brass. Ordered to be kept by the towns.

1492. Caxton died. The letter Caxton used was, according to Mores, of the sort called secretary. Of this he had two founts. Dibdin says Caxton's letter was peculiar to himself, and a mixture of secretary and gothic as to shape. He had a way of joining two letters which made the types appear not to have been cast. Afterwards his types came nearer to the English face: he had three founts of great primer, a rude one which he used about 1474, a second something better, and the third cut about 1488, more nearly approaching to the English face than those mentioned. He had two founts of English or pica, the latest and best cut about 1482; one of double pica, which is good, and first appeared in 1490; and one of long primer. They resemble the usual character of the manuscripts of that age.

Dibdin thinks that Mores is mistaken in calling the type of 1490 a new type, as the greatest part of Caxton's preceding books exhibit precisely the same character. He supposes Mores had seen a fine impression and a careless one. The bulkier works of Caxton seem to have been uniformly printed with his smallest types. He had probably a larger fount of this letter. Caxton's type is inferior to that of some foreign printers of the same age; though much of the beauty of foreign letter of this period, it must also be admitted, is produced from the excellence of the paper and press-work. The workmen in the Italian and Nuremberg offices were regularly trained to the mystery.

Perfect order and symmetry of press-work, which is so apparent in the pages of foreign printed books, are not seen in Caxton's. His uniform rejection of Roman letter, which has been noticed as a blemish in his typographical reputation, should, however, be placed only to a difference of taste.

In good copies of his books, his type, notwithstanding its imperfections, has a bold and rich effect, which renders the perusal of them less painful to some persons than that of many foreign productions, where the angular sharpness of the letter somewhat dazzles and hurts the eye. In the ink which he used, (that material part of printing, now too little attended to,) he has been uniformly excelled by a crowd of foreign printers. Instead of a steady, even, and rich effect, we frequently witness a pale, jaundiced, and forbidding aspect in many of his volumes; from which it is probable that he was left at the mercy of his agents to receive whatever ink had been discarded by other printers. The paper used by Caxton is made of linen rags, and is very fine and good, and has much the appearance of the thin vellum on which books of that age were written. It was imported. His books abound in cuts, of which the earlier specimens are thought to be the works of some foreign engravers. The cuts for his second edition of the Canterbury Tales may perhaps be considered the genuine invention and handiwork of a native engraver; and considering the rude state of the elegant and useful arts in this country at the time, some of them may be said not to be without spirit and characteristic propriety.

Wynkyn de Worde, his servant and successor, made considerable advances beyond his master in all parts of the art, and enriched his foundry with a variety of new types. His letter was of the square **Engliſh**, or black face, and has been the model for his successors in the art. He is said to have been the first who brought into England the use of the round *Roman* letter, which was first cut abroad by Sweyheim and Pannartz, under the patronage of the Bishop of Aleria, who was librarian to Pope Paul II. About the first Roman letter used in England is a marginal quotation, in pica, at the latter end of the second part of a book entitled the "Extirpation of Ignorancie, compyled by Sir Paule Bushe, preest," about 1518, printed by Pynson. His founts were one of double pica and two of great primer, both good, but one thicker than the other; an English which is rudish; a good English, cut about 1496; a long primer and a brevier, which are well enough.

The earliest use of musical types may be fixed about 1495. They occur in the Polychronicon of Higden, printed by De Worde; but are exceedingly rude and clumsy. They do not, however, quite come up to the modern notion of cast printing type; for one type seems to comprise several notes.

Caxton, Wynkyn de Worde, and Pynson, are here considered as type founders as well as printers. Their successors separated the arts, and were founders or printers only.

Most of the ancient printers styled themselves "printers and binders," as well as booksellers. The books were bound at their office. Bookbinding was early considered a not unsuitable amusement for a gentleman; thus: "book illuminated, bound, and finished, by Henry Cremer, vicar of the Collegiate Church of St. Stephen."

1494. An improvement introduced in the manufacture of fustians, which at this time were brought in the rough state from abroad and finished here; the act says that, "fustians brought from beyond sea should be the most profitable cloth for doublets and other wearing cloths used by the common people of this realm, and formerly they were truly wrought and shorn by the broad shear and no other deceitful mean; now diverse persons have with undue sleights and means, imagined and contrived instruments of iron, with which irons in the highest and most secret parts of their houses, they strike and draw the said irons over the said fustians unshorn, by which means they pluck off both the nap and cotton of the said fustians, and break commonly both the grounds and thread asunder; and after, by crafty sleeking, they make the same fustians appear to the common people fine, whole and sound. And also they raise up the cotton of such fustians, and then take a lighted candle and set it in the fustian burning, which singeth and burneth away the cotton from the said fustian from the one end to the other, down to the hard threads, instead of shearing; and after that put them in colour, and so subtley dress them that their false work cannot be espied without it be by workmen, shearers, or by weavers of the same; and so by such subtleties, whereas fustians made into doublets were wont and might endure by the space of two years and more, will not endure now whole by the space of four months, to the great hurt of the poor commons and serving men." Shearing only was to be practised under a penalty.

Robert Borthwick, Master of the Artillery to James IV. of Scotland, cast, among others, the beautiful train of guns called the 'Seven Sisters,' which were greatly admired by the victors whose prize they became some years after this at the battle of Flodden.

1495. A ludicrous instance of the extent to which the system of gild exclusion was carried was exhibited at Norwich. After the act was obtained imposing a heavy penalty on those who singed fustians, the woollen shearmen of Norwich managed to procure an act to prevent any from shearing woollens who had not served a seven years' apprenticeship to the mystery. "Time out of mind, artificers of the shearman's craft had always used to shear as well worsteds, stamins, fustians, and all other woollen cloths, and all apprentices bound to shearman's craft were bound to it generally; but in order to bring the trade into few hands, the worsted shearmen elected a master and wardens, and made bye-laws for the new company, and separated themselves from the shearmen of other stuffs, admitted into their fraternity whom they pleased, and would not admit others who had sufficient or equal cunning with the admitted, unless they would pay great and unsupportable fines. In consequence of which many left the town, and the houses were empty. The magistrates of Norwich applied to Parliament, and the bill was repealed on the ground of the worsted shearmen having exceeded their powers."

1507. A paper-mill erected at Hertford. The first paper made in England, and manufactured here by John Tate, junior, was used by Wynkyn de Worde, in an edition of a book entitled "Bartholomeus de Proprietatibus rerum." It was probably inferior to that imported, and higher priced, for the Bible was attempted to be printed at Paris, because paper there was more abundant, and better.

1508. The use of the cross-bow forbidden in England, under a heavy penalty.

This was an age of splendour in armour, as the preceding one had been of elegance. "Fancy," says Meyrick, "ran riot."

The attempts now made to give a raised surface to the steel by hammering it out from underneath was an Italian invention, that led to the adoption of bas reliefs, of which Skelton has given engravings of some existing specimens. The manufacture of plate armour was a distinct trade from that of making interlaced rings for shirts and tippets of mail like those of the Asiatics.

1512. A new foreign fashion was affecting the old manufacture of woollen caps; and it was enacted that no wrought caps or hats were to be imported; these were felt hats.

Soap first boiled in London, according to Stow; before this, it was supplied with Castile soap from Spain, and " gray sope" from Bristol.

Glass mirrors not yet in use. Henry VIII., in his bed-room at Hampton Court, had a " steele glass covered with yellow vellat," looking glasses used at this time only by ladies, being for the most part small and kept in cases, and locked up with their other trinkets or worn in the pocket, as in the olden time.

Platters, basins, salts, mustard pots, dishes and spoons, are now made of tin or pewter, and " a faire garnishe of pewter on his cowborde," reckoned a mark of a man's respectability. Many of the articles seem to have been imported, and even tin itself.

Glazed lanthorns used to light some of the streets.

1513. Foreign articles imported, cloth of gold or silver, vaudekin velvet, damask, sattin, sarcenet, furston, camblet, and other clothes of silk: 3000 or 4000 pieces imported in one ship. An improvement in the method of dressing woollen cloth brings forth an act to prevent its being followed. " Some persons dry calendar worsteds with gums, oils, and presses, so that a coarse piece of worsted, not being past the value of 24*s.* viij*d.*, is and shall be made by their gums, oils, and presses to show the value of 40 shillings or better, and if the same worsted dry calandered take any wet incontinent it will show spotty and foul, and ever after continue foul and will not endure." If " the *strangers* called dry calanderers, who are come unto this realm, use to the great hurt of the said commonweal the dry calandering," they are to forfeit 100 shillings. " And as the old way called wet calandering hath been used well and substantially for times past, and yet is by persons having cunning in the same, none are to calander cloth who have not served seven years' apprenticeship, under a penalty of C shillings."

1515. There was exhibited to Henry VIII., at Greenwich, " arrows that whistled by the craft of the head, so that the noise was strange and great, and much pleased the king and queen, and all the company."

Tenters or winches for straining woollen cloth not to be used under a penalty, in order that the cloth may not shrink in using.

1521. Before this time brass ordnance was founded by foreigners. Stow says that John Owen began to found brass ordnance, and that he was the first Englishman who ever made that kind of artillery in England.

A great deal of the finer armour of this period has the arms of the city of Nuremberg, where, as well as at Milan, was a famous foundery at this time for arms and armour.

The art of inlaying with gold, called damasquinée, was borrowed from the Asiatics, and introduced by Benevenuto Cellini. Holbein designed swords and daggers for the court of Henry VIII. At Hull there is a sabre which Henry presented to a favourite, with a long motto and a representation of the siege of Boulogne, inlaid with gold on its blade. Was this a home production?

Bell founding followed. Bell metal and other broken metal were allowed to be exported hitherto, but it being discovered that it was applied to found guns abroad, "brass, copper, latten, bell metal, pan metal, gun metal, and shroff metal," are prohibited to be exported.

First copper-plate impressions executed in this country by means of a roller are supposed to be the frontispieces of Galenius de Temperamentis, printed at Cambridge in this year.

1524. Began making Spanish felts in England, by Spaniards and Dutchmen; before which time the English used to ride, and go winter and summer, in "knit caps, clothe hoodes, and the best sort in thromed hats." These were worn long afterwards by the lowest sort of people; a century after this, a country ale-house wife is described putting on her fairest smoke, and her square thrumed hat.

Hops brought from Artois first planted. Upon that, and some other importations, the following rime was made as an aid to the memory:—

> Turkies, carpes, piccarels hopes for beere,
> Came into England all in one yeere.

1529. The decree made in the Star Chamber mentions the great increase of foreigners, who do not regard the laws made concerning them; and when any search was made by the corporation or crafts they gave information to each other, and concealed the number of their servants, besides making deceitful wares. This decree also charged them with "subtilly conveying over sea, bacon, cheese, powdered beef, mutton, and other commodities, by which they increase in great riches; and when they have gathered much money they, against our laws, convey it over sea, and there purchase themselves lands and tenements, and with the residue live thereby, and sometimes convert part thereof to the use of our enemies in these parts, and so our poor subjects, handicraftsmen, be sore impoverished, minished, and almost utterly decayed and destroyed; and many of them, for lack of occupation in the said handicrafts be constrained to live in idleness, by occasion whereof they do continually fall to theft, murder, and other great offences, and consequently in great numbers be put to death by our laws." No alien therefore was to keep more than two alien servants, but they were at liberty to keep as many English born apprentices as they may lawfully get—but they were debarred from setting up or keeping any house, shop, or chamber in London, or in any city, town, or village in the kingdom.

This extraordinary edict resembles other acts of this age against the aliens, which have more the aspect of indictments than laws.

1530. Notwithstanding the law made eighteen years before, felt hats were now imported. By the new law, outlandish hats, as they are called, are to be sold at the prices specified in the act, which were fixed low to prevent their importation, by diminishing the profit.

Linen in large quantities now imported from Flanders, even the coarsest dowlas, or sailcloth.

1532. The prejudice against some dye-woods removed. " No woollen cloth caps or hats to be dyed unless the same was perfectly grained, boiled, or maddered upon the wood with good cork or orchal." But " no dyer shall occupy Brazile in dyeing woollen or hats, nor any thing but grain (cochineal) in the dyeing of scarlet."

The manufacture of pewter vessels was now considerable, and the ware had been exported; many English workmen having been allured into strange regions, says the act, so that a great number of vessels are now imported instead of being exported as platters, dishes, saucers, pots, basins, ewers, flagons, goblets, salts, salt-cellars, spoons; no pewterer was henceforth to take an alien apprentice. Although the king openly encouraged and invited foreign workmen to come into the country, the English pewterers in foreign countries " were to have notice sent them under the seal of the warden of the craft to return to England, or be reputed no Englishmen, and out of the king's protection."

1533. Knit woollen hose so common that they were sold for two shillings a pair, and children's stockings at sixpence a pair. The invention is said, with great probability, to be a Scotch one.

The Bristol dyers were noted for the excellence of one of their colours. Skelton names it—

> " Her kyrtle was of Bristowe red."

This was the period of inconsistency in legislation. Under Henry VIII. there was an outcry against the practice then general of converting arable into pasture farms, and consequently consolidating many into one, or as the act says, " Persons to whom God of his goodness hath disposed great plenty and abundance of moveable substance, have of late invented and practised ways, and how they might accumulate and gather together in few hands, as well great multitudes of farms as great plenty of cattle, especially sheep; and by putting such land to pasture and not to tillage increased old rates of rent, and by excessive fines, so that no poor man could meddle with it, and enhanced the prices of all manner of corn, cattle, wool, pigs, geese, hens, chickens, eggs, almost double price which have been accustomed. Owing to the great profit that cometh of sheep now in few persons' hands in respect of whole numbers of the king's subjects, some have 24,000, some 10,000, and some 5,000 and less, so that a good sheep that sold for *2s.* *4d.* or *3s.*, is now sold for *4s.*, *5s.*, or *6s.*; and a stone of clothing wool that used to sell for *1s.* *6d.* or *1s.* *8d.* is now sold for *3s.* *8d.* or *4s.*; and in other places, where it has sold for *2s.* or *3s.*, it sells for *4s.* *8d.* or *5s.*," which change, as showing the increased demand and better position of the country, is, however, by the Act said to be "used to the high displeasure of Almighty God—to the decay of the hospitality of the realm—to the decay of the king's people—and to the let of the cloth-maker." So that in future it was forbidden any one generally to have more than 2,000 sheep.

1534. Cross-bow, called the latch, had its windlass let into its stock to save the trouble of putting it on and off; the handle was weakened by this construction, and it was superseded by the goat's-foot latch.

1537. Thomas Hinde was the first print-seller in London, then John Humble and Thomas Geele, who were cotemporaries. Among early print-sellers several exercised the art of engraving themselves, and kept engravers as journeymen under their roof. On the impressions there are found different notifications, pinxit, sculpsit, excudebat, and fecit.

1540. The arts, says Strype, flourished so much in convents to the last, that one Gyford, a visitor employed by Thomas Cromwell to make a report of the state of these societies previous to their suppression, pleads in behalf of the house of Wolstrop, that there was not one religious person there but that he could and did use either embrotherynge, writing books with very fair hand, making their own garments, carving, painting, graffing.

At this period we had no cabbages, turnips, nor salads, and a few only of the fruits that are now common in most gardens.

Flemish manufactures imported in large quantities, particularly linen. Shortly after this Henry VIII. issued a proclamation to enforce the sowing of hemp and flax, as the nation was overrun with foreign productions.

1541. No one was to buy worsted yarn in Norfolk but only such weavers as shall weave it into cloth in Norwich, or some city or *town* in the country.

1542. "It may easily be proved," says Fuller, "that about this time strangers have sold in this land pinnes to the value of threescore thousand pounds a yeare." By the law made this year they were to be "double headed, and have the head soldered to the shank of the pins, well smoothed, the shank well shaven, the point well and round filed, canted, and sharped." A heavy penalty was imposed on the pinner if he deviated from these instructions; pins so made excelled those of all nations, and to encourage him to work up to the standard foreign pins were prohibited. The pinners, however, either became greedy when they found the market wholly in their hands, or else were unable to produce the quantity required to meet the demand; there was a scarcity of pins; and people, as might have been anticipated, were not supplied with them at reasonable prices, or of a good quality as before. The Act was repealed in 1545, because the "pinners had not kept their promise to the public."

1543. Bomb-shells.—"The king, Henry VIII., minding," as Stowe has it, "his wars with France, made great preparations and provisions, as well of munitions and artillery. Among which at that time one Peter Collen, a gunsmith, conferring with Peter Bawd, devised or caused to be made certain mortar pieces, being at the mouth from eleven to nine inches wide; for the use whereof the said Peter caused to be made certain hollow shot of cast iron, to be stuffed with fyrework, whereof the bigger sort for the same has screws of iron to receive a match to carry fyre for to break in small pieces the said hollow shot, whereof the smallest piece hitting a man would kill or spoyl him[a]. And after the king's return from Bullen, the said Peter Bawd, by himself, did make certain ordnance of cast yron of divers sortes and formes, as fawconet, falcons, minions, sakers, and other pieces."

1545. Thomas Gemenas, or Gemini, introduced printing plates with the *rolling press*. Rolling presses were only kept in the houses of the venders of prints.

1546. A printing press set up at Bristol Castle, which is said to be used "dayly to the honor of God." At Norwich one had been set up in 1530.

By law all wool growers were to sell their wool within a year after shearing. Some former prohibitions were annulled; any one now was empowered to buy and sell wool in open market; it had been formerly confined to merchants of the staple.

1547. Ordnance made of gun metal, no guns of cast iron except in English ships, or of English foundry.

1548. "Persons," says the Act, "who take upon them the mystery of malt making, have by their insatiable, covetous, and greedy minds, made much malt impure and unseasonable;" they made the "malt in eight or nine days, where it cannot be perfectly made unless it have the space of twenty-one days,"—also divers do slackly and deceitfully dry the malt, so that they would have an inordinate increase thereof by swelling, and which "not being sufficiently dried cannot be kept, but it will be musty and full of weevils; from malt so made brewers cannot make the same quantity of drink from fifty quarters as from forty quarters." They also mixed "good with evil malt;" no malt to be sold that is not trodden, rubbed, and fanned. If it contains half a peck of dust in the quarter the maltster is to be fined.

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[a] Valturinus assigns the invention to an earlier period. His book, published in 1472, has an engraving of a mortar by which brazen cannon-balls, filled with powder and with fuel, formed of an inflammable spunge, may be ejected. And Nicholas Tartaglia, in 1538, shows a mortar throwing a burning ball.

No tanner to sell leather tanned and mixed with ashen bark, lapworth meal, or culver dung, nor unless it have lain in the tan oozes for three-quarters of a year at least, nor shall he overburn any hides with lime, nor set his fats in tanhills, nor put any hot liquor or oozes in the fats wherein hides shall be put in tanning, nor practise any other way for the speedy tanning of hides. Or cut any hide of steer or cow into clout leather; or tan any sheepskins, on pain of forfeiting the leather.

Forging iron gadds to imitate steel prohibited. "Iron gadds, called bilboa iron, like to the fashion and manner of gads of steel, whereby the greatest part of edged tools that have been made of them have no value or goodness." This was apparently in imitation of the Spanish gadds.

White ashes had previously been made and exported, but this having enhanced their price, and "being necessary for the whiting of linen cloth, dying and scouring woollen cloth," they are no longer to be carried beyond seas.

Judge-marshal Patten, who accompanied the Protector's expedition into Scotland, says "the Scots come with swords all broad and thin, of exceeding good temper, and universally so made to slice that I never saw none so good, so I think it hard to devise a better."

1550. Musical moveable printing types greatly improved by Grafton, who had a patent granted to him this year for printing the Statute Book. The types were used in the Book of Common Prayer, composed by John Marbeck, organist of Windsor.

The suppression of the monasteries, which is considered to have improved the manufactures and prosperity of trade in general, had an opposite effect on that of many communities. Among other towns Coventry was a grievous sufferer by this cruel measure. The ruin of its grand and famous monastery, and other religious houses, occasioned an interruption of the great concourse of people that used to resort thither, so that the trade of the town fell off, and many thousands of its inhabitants were constrained to forsake the city and to seek their livelihood elsewhere, insomuch that John Hales, (called by Leland, Hales with the club foot,) a noted man in that time, and whose memory is still savoury in Coventry, represented to the Duke of Somerset that there was not then 3,000 inhabitants in the town, whereas within memory there had been 15,000. It revived a little afterwards by making cloth and caps, but in Dugdale's time these had partially decayed, and he observed, "it had not a little fallen from the glory it anciently had."

The dissolution of religious houses also threw, as we have seen, a great number of persons on the public, unfitted almost for the struggles of life, and helpless from their previous habits of life; and what greatly aggravated the evil, the poor of all descriptions who were dependent on their bounty were left uncared for. The Reformation introduced a purer form of Christianity, and abolished many corruptions; but in these times at least it also destroyed that heavenly charity, that felt for and shed its blessings on the poor, and which stood as a protector between the destitute and the grinding inherent selfishness and inhumanity of society. To check mendicity, that had been greatly increased by the reckless destruction of funds hitherto devoted to charity, for the harpies to whom they had been alienated, "kept no hospitality for the poor," the virtuous Edward VI., guided by Cranmer and Ridley, men imbued with the spirit of holiness, sanctioned an Act for the punishment of rogues and vagabonds, which orders that "if any person brought before two justices any runagate servant or other who lived loiteringly and idle for the space of three days, they were to cause him to be marked with V on the breast with a red-hot iron, and adjudged to be the slave to the person who brought him, and who may cause him to work by chaining or otherwise." So little practical effect had the Reformation on this prince and his counsellors in teaching them humanity towards their poorer fellow creatures.

1551. Great numbers of foreign workmen invited by Edward VI. into England.

It was a strange propensity among municipalities in these times, that as soon as a manufacture had made some progress they would form it into a corporation. The hat-makers went and settled out of Norwich city, to escape subjection to its fiscal law; but the iron hand of authority reached them by an Act declaring that no one was to make hats except in some *city*, or corporate, or market town, which brought them back to the corporation bondage[a].

No stranger was to buy English horns unwrought, or gathered in London or within 24 miles of it. All horns were to be sold in London, or at the fairs of Sturbridge and Ely; what the horners refuse may be exported.

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[a] "Gild or geld signifieth," says Dugdale, "money, because that such as were either for charity, religion, or merchandize sake associated, did cast their money, goods, yea, and sometimes lands, together, for the publique support of their common charge; these had their annual feasts and neighbourlike meetings, which custom, as Sir Henry Spelman observes, was very anciently used by the Franks, Longobards, and other nations, and is still continued by the Germans, who call the frequent yearly banquets of the country people made at their common charge, *gilden*. As to the direct time when these had first beginning in England, there is nothing of certainty to be found, forasmuch as they were in use long before any formal license were granted unto them for such meetings, or for conferring lands or rent towards the support of the publique expenses in what sort soever."

The king wore cloth hose only, or hose cut out of ell broad taffety, unless by great chance there came a pair of silk stockings from France.

As an event of importance in this king's life it is stated that he had one pair of long Spanish silk hose sent him for a present by Thomas Gresham.

In the time of Richard III., all "strangers coming into England, might bring books in at their pleasure, but there has come sithen the same a marvellous number. Then few books and few printers, now a great number cunning and expert in the said science or craft of printing as any stranger. Great numbers now live by the craft and mystery of binding books. Persons bring from beyond sea a great plenty of printed books, not only in the Latin tongue, but also in our maternal English tongue; some bound in boards, some in leather, some in parchment, and binders of books having no other faculty wherewith to get their living are like to be undone." And therefore the Act says, "no one is to sell a book printed beyond sea that is bound." And if binders "enhance the price of books, it may be reduced by application to the great officers of the Crown."

One of the first acts of Philip and Mary was to remove some of the absurd restrictions that were now seen to cramp the freedom of trade. The Act of Edward VI., by which no one was to make cloth who had not been apprenticed to it for seven years was annulled; the Act says that "some who had married clothiers' wives for 20 years were obliged to leave off the business," on that account; and forasmuch as the perfect and principal ground of cloth making is the true *sorting of wools*, and the experience thereof consisteth of women and children, and not in apprentices, every person inhabiting where cloth making hath been used may henceforth make all manner of broad cloths, and put them to weaving, walking, fulling, dyeing, and shearing, so that the cloths be substantially made and bearing lawful length, breadth, and weight. And this was about the first glimpse of a wise policy in the history of English manufacturing labour.

1554. Fulling mills have gained so much favour over the process by hands and feet, that the law of 1483 against them is again revived.

A fabric called Russels-satins, and satins reverses, which for many years had been made abroad of Norwich wool, was now manufactured to greater perfection at Norwich. The mayor and aldermen succeeded in being made a body corporate under the name of "the fellowship of the mystery of sattins-russels."

1555. The weavers throughout the country complained that the wealthy and large clothiers oppressed them in various ways, particularly by keeping in their houses "a great many journeymen and unskilful persons, to the decay of a great number of artificers brought up in the science of weaving, their families and households." Others engrossed looms into their hands, and let them out to poor artificers at rates so unreasonable that they could not be paid, and other clothiers gave less for weaving than in times past.

It was made law that in future no person using the feat or mystery of cloth making, and dwelling *out* of a city, borough corporate or market town, shall have more than one woollen loom, nor receive profit directly or indirectly by letting or setting any loom. No woollen weaver dwelling out of a town shall keep at any one time more than two woollen looms, or receive gain or emolument in any way from more than two looms at one time.

Nor while he is a weaver, and not a cloth maker, shall he be a tucker, fuller, or dyer.

Nor shall a tucker, fuller, or dyer, have a loom in his house.

No cloth maker shall weave or cause to be woven any kind of broad white woollen cloth, but only in a city, borough, town corporate, or market town, or in such places as have had heretofore for ten years last woollen cloths made in them, and no one was to have more than two apprentices at one time.

In this way did the whole community employed in the woollen manufacture sacrifice themselves and their posterity for generations to the corporation Moloch.

Walter Rippon made a coach for the Earl of Rutland, which was the first made in England. A few years after he made a hollow turning coach for the Queen. It was a long time after this before the coach-box was added. Great persons were carried in a coach or hanging waggon with six horses, lesser folks rode with two horses.

1557. Tanners were now permitted to use pigeon's dung, meal, and lapwort in the preparation of leather.

1558. "Lecoras" began to be planted and grown in England.

The destruction of wood by the iron works so great as to occasion a scarcity for building purposes and fuel. It was now forbidden to cut wood for the forges that was more than one foot square at the stubb.

Coarse glass making, says Fuller, is of great antiquity in Sussex, yet the first making of Venice glass in England, began at the Crotchet Friars in London, by one Jacob Venaline, an Italian.

Splints introduced, a variety of armour made of overlapping plates like the shell of a lobster, enabled the armour to give way to any motion of the body.

Russet armour, from being more easily kept clean than bright polished armour, introduced, having a more beautiful effect with gold, with which it admirably harmonized, than black; it soon superseded that colour. It was produced by oxidising, and then smoothing the surface of the metal.

"Certain evil-disposed persons," says the Act, "who buy and engross great store of linen cloth, do cast the pieces of cloth over a beam or piece of timber made for their purpose, and do by sundry devices rack, stretch and draw the same both of length and breadth, and that done, do then with battledores, pieces of timber and wood, and other things sore beat the same, ever casting thereupon certain deceitful liquors mingled with chalk and other like things, whereby the said cloth is not only made to seem much thicker and finer to the eye than it is indeed, but also the thread thereof being so loosed and made weak, that after three and four washings it will hardly hold together, to the great loss and hindrance of the natives." These practices are forbidden.

William Sanderson is described as "a man who by setting forth globes hath well deserved in the studies of geography." Sanderson fitted out two ships at his own expense, with which Davis tried to find out a way to the East Indies by the upper part of America.

1559. In this year an extraordinary attempt was made by one part of society to promote by force its interest and convenience at the expense of the interest and convenience of another portion of its members. A Bill was brought into Parliament, and read three times, to *compel* artificers and craftsmen who might be living in the inland parts of Kent and Sussex, to dwell in towns on the seacoast. The townsmen, no doubt, required the assistance of such mechanics, and their not having it would now be considered a proof either of their unwillingness or inability to pay liberally for it, or of the towns being less prosperous than heretofore, and having "many empty houses to let."

Patent to make bowstrings granted to GEORGE FULCET; at his death it was granted to JOHN MANBY for his life.

The thumb ring now seen on sword-hilts.

Leather so scarce, that to keep down its price, carrying leather, tallow, and raw hides out of the kingdom was made felony. The importation of wrought articles of leather was at the same time prohibited.

1560. Mrs. Montague, her highness's silk-woman, presented Queen Elizabeth with a pair of black silk knit stockings, which after a few days' wearing pleased her highness so much that she sent to Mrs. Montague for more. The queen, who was not ignorant of the attraction of a smart-looking foot and ankle, liked them so that she would not henceforth wear any more cloth hose.

Moveable musical printing types considerably improved by the industrious JOHN DAY, who in this year published the church service in three or four parts; and in

1562, the whole Book of Psalms in metre, with apt notes to sing them withal. Day had a patent, which in 1577 was renewed to him and his son for their joint lives, but no longer.

1561. A great improvement made in the art of coining, by the introduction of the mill and screw coining press used in the French mint, and perhaps invented there. It was used along with the old method by hammer. It consisted of a screw to which the upper or "punching die" was connected, worked by a fly, which forced the die attached to it with considerable effect on the other die fixed below, and producing a good impression with one blow on both sides of the piece of gold or silver placed between them, and with a great saving of time. Before this mill was used the edges of the hammered money were in a rude imperfect state. The earliest specimen of "milled money" under Elizabeth has a graining to form a regular circle on the outside of the legend quite to the edge of the coin.

Queen Elizabeth, by the advice of her council, this year brought several Germans into England, who were experienced in mining.

1562. The girdlers, cutlers, saddlers, glovers, and point makers, suffering from the price of iron and leather, and the competition of foreign wares, the Act prohibits the importation of girdles and their harness, rapiers, daggers, knives, hilts, pommels, lockets, chapes, dagger blades, handles, scabbards, sheaths for knives, saddles, horse harness, stirrups, bits, gloves, points, leather laces, or pins, as "well for sustentation of the handicraftsmen themselves, wives and families, as for a good education of a great part of the youth of the kingdom, who are trained to the said sciences and exercises, otherwise the exquisite knowledge thereof would in a short time fall to decay."

The exportation of wool and skins was strictly prohibited. No one was to pull, shear, clip, or take beyond sea the wool of any sheep or lambskin, nor buy the skin of any stag, hind, buck, doe, goat, fawn, unless they make thereof tawed or lawfully tanned leather, under heavy penalties.

It would seem that the difficulty of getting the fleece had prompted foreigners to attempt improving their native breeds of sheep by crossing them with the English sheep. The practice of exporting live sheep gave rise to a rigorous and barbarous law in 1565. No one by the Act "was to carry over sea, rams, lambs, or sheep alive; aiders, abettors, procurers, and comforters were to be sent to prison for a year without bail or mainprize; and on being set at liberty, the offender was to be carried to some town, and his right hand was to be cut off and nailed up in the most conspicuous spot of the market; and if he eftsoons offended he was to be adjudged a felon, and suffer death accordingly."

1563. The trade of Norwich declining, the magistrates invited a number of manufacturers from the Low Countries, who came over to the number of three hundred, and soon after they amounted to one thousand. They set up the making of baizes, serges, arras, mochades, caungeantries, tufted mochades, curelles, and all other works mingled with silks, saietrie, and linen yarn.

RICHARD MATTHEWS, a cutler at Fleete Bridge; patent for the sole making of fine knives, with bone hafts and plates of latten and tin; because, as the patent stated, he brought the first use of them from beyond sea. He also obtained, according to Stowe, a prohibition against " all strangers and others, for bringing any knives from beyond seas, which, until that time, (notwithstanding the general prohibition against importing wrought-iron articles,) were brought into this land by shipps lading from Flanders and other places. Albeit, at that time and for many hundred years before, there were made in divers parts of the kingdom many coarse and uncomely knives." "The wardens of the Company of Cutlers," says Noy, "showed that they did use to make knives before, though not with such hafts. That such a slight difference or invention should be no cause to restrain them. Whereupon he could never have the benefit of this patent, although he laboured very greatly therein." The prohibition does not appear to have been touched.

MATTHEWS marked his fine knives and cutlery with a half moon. They were so excellent that this mark was put, *pro formâ*, on knives for two centuries afterwards.

1564. One Mistress Dinghen Vanden Plasse, daughter to a worshipful knight at Teenen, in Flanders, came to London, and professed herself a starcher, in which she excelled. Ladies sent their cambric ruffs to Mrs. Dinghen to be stiffened, and rewarded her liberally. They also sent their daughters and kinswomen to be taught. Mrs. Dinghen charged five pounds each to teach them to starch, and one pound to teach them how to seethe the starch. Before this Holland ruffs were worn, as none could properly stiffen lawn or cambric ruffs. The wife of Guillan, her coachman, was the first clear-starcher Elizabeth had.

To two of the foreign miners, HOUGHSETTER and THURLAND, brought over by the queen, she granted a patent to search for mines and ewers of gold, silver, quicksilver and copper, in eight counties, and to convert the proceeds to their own use, with the reservation of a certain portion to the queen. They were to make compensation in certain cases to the owners of the land, and were not to dig or undermine houses or castles. All persons were prohibited digging for any kind of ore without the licence of Houghsetter.

This German established copper works at Keswick, in Northumberland. He was opposed by the Earl of Northumberland, but the judges gave their decision against the earl, and in 1565 the queen formed the patentees into a corporation.

They found an abundance of rich copper ore, which for many years afforded great profit to themselves and to the nation, until by the death of the first German immigrant workmen, and neglect of continuing the stock, and also a want of fuel in those parts the works after this greatly languished. These and some iron mines of the company gave regular daily employment to upwards of 4,000 persons.

Another work connected with the same company was at Whitbrook and Tintorn, in Monmouth, for the working of iron wire for the cards used in the manufacture of woollen cloth. This also was a most productive concern, but its prosperity was impaired from the effect of some Acts of Parliament connected with the regulation of this manufacture.

The silver mines in Cardiganshire worked by this company, were situated on the site of the "old Roman works," in the township of "Skibery Coed." These were erected by Houghsetter, and also brought large sums to the company. 140 years after this period Houghsetter's name and family were said to be then distinguished in the district.

1565. Before this, no tanner durst, under a heavy penalty, tan sheepskins. A new trade had lately been introduced and made some progress; for now, "tawed leather may be made of sheepskin and lambskin, and many thousands of people," says the Act, "are set to work by converting of sheepskins and lambskins into tawed leather and *parchment*."

Patent to JOHN HUMPHRY, in the Tower, for the sole use of a sieve, or instrument for melting of lead, "supposing that it was of his own invention." Because others used the like instrument in Derbyshire contrary to his patent, he sued them in the Exchequer Chamber. In court, the question was, as stated by Noy, "whether it was newly invented by him, whereby he might have the sole privilege; or else used before at Mendiff, in the west country,—which, if it were there before, the court was of opinion he should not have the sole use thereof."

During the angry debates raised at this time in Parliament, by the queen's refusal to name a successor, and at her "commands" to the House on that occasion, expressions of disapprobation were uttered regarding some "patents of monopoly" which had recently been granted.

In the Speaker's address to her Majesty, at the close of the session, he touched obliquely, but firmly, on the right that was violated in these grants. "As for the common law," said he, "it is so grounded on God's laws and nature that three several nations governing here, have all allowed the same, which is not inferior, but rather superior, and more indifferent than any other law. For by our common law, although there be for the prince provided many princely prerogatives and royalties, yet it is not such as the prince can take money, or other things, or do as he will at his own pleasure without order; but quietly to suffer his subjects to enjoy their own, without wrongful oppression, wherein other princes by their liberty do take as pleaseth them."

To these pithy observations the Lord Keeper Bacon, who was standing near, was formally desired by her Majesty to make reply. "Politic orders be rules," says Sir Nicholas, "of all good acts, and touching those that you have made to the overthrowing of good laws, they deserve reproof, as well as the others deserve praise. In which like case you err in bringing her Majesty's prerogative into question, and for that thing wherein she meant not to hurt any of your liberties. And again, the grant of her *letters patent* in question is not a little marvail, for that therein you find fault which is now no new devised thing, but such as afore this time hath been used and put in practice. Howbeit her Majesty's nature is mild and full of clemency, so that she is loth herein to be austere, and therefore, though at this time she suffer you all to depart quietly unto your countries for your amendment, yet, as it is needful, so she hopeth that the offenders will use themselves well."

Elizabeth, however, was not satisfied with the tone of the venerable chancellor's reply. After giving assent to some bills, she unexpectedly rose from her seat, and said—

"Although the Lord Keeper hath, according to order, very well answered in my name; yet, as a paraphrasis, I have a few words further to speak to you, notwithstanding I have not been used, nor love to do it in such open assemblies; yet now, not to the end to amend his talk, but remembering that commonly princes' own words are better printed in the hearers' memory than those spoken by their command, I mean to say thus much unto you.—I have in this assembly found so much dissimulation where I always professed plainness, that I marvail thereat,—yea, two faces under one hood, and the body rotten, being covered with two visors, succession and liberty; which they determined must be either presently granted, denied, or deferred. In granting whereof they had their desires; and denying or deferring thereof, (those things being so plausible, as indeed to all men they are,) they thought to work me that mischief which never foreign enemy could bring to pass, which is, the hatred of my commons. But, alas, they began to pierce the vessel before the wine was fined, and began a thing not foreseeing the end. Now, by this means, I have seen my well-willers from mine enemies, and can, as me seemeth, very well divide the House into four. First, the broachers and workers thereof, who are in the greatest fault. Secondly, the speakers, who by eloquent tales persuaded others. Thirdly, the agreers, who being so light of credit that the eloquence of the tales so overcame them that they gave more credit thereunto than unto their own wits. And, lastly, those that sat still and mute, and meddled not therewith, but rather wondered, disallowing the matter—who, in my opinion, are most to be excused.

"But do you think that I am unmindful of your surety by succession, wherein is all my care, considering I know myself to be mortal? No, I warrant you. Or, that I went about to break your liberties? No, it never was in my meaning, but to stay you before you fell into the ditch, for all things have their time; and although, perhaps, you may have one after me better learned or wiser, yet, I assure you, none more careful over you. And therefore, henceforth, whether I live to see the like assembly or no, or whoever it be, yet beware, however, you prove your prince's patience as you have done mine. And now, to conclude all this, notwithstanding, not meaning to make a Lent of Christmas, the most part of you may assure yourselves that you depart in your prince's grace."

This gruff address being ended, the royal virgin sat down and spake openly to the Lord Keeper, "My Lord, you will do as I bade."—Who then said, aloud, "The Queen's Majesty hath agreed to dissolve this Parliament, therefore every man may take his ease and depart at his pleasure." "And the queen rose," says the historian, "and went and shifted her, and took her barge and returned to the court."

Norwich city being much in distress from the decay of the worsted manufacture, which was now at so low an ebb that many, says Blomefield, were forced to leave their houses, and go into the country to get their bread; after many consultations how to revive the prosperity of the community, the mayor and a deputation waited on the Duke of Norfolk, who was then at his palace in the city, and it was resolved to invite some strangers of the Low Countries, who, by leave of the queen, had come to Sandwich and London for refuge from the Duke of Alva.

Upon application to the queen by the Duke of Norfolk, she gave letters patent for thirty master workmen, each with ten servants, to settle in the city, who set up the making of baizes, serges, arras, mochades and such like, which gave employment to a great many hands. Houses which had fallen into decay were now repaired and inhabited, and both city and country grew rich, the latter by the great demand for their farm produce, and the former from the profits of this new way of trade.

1566. Letters patent granted to SIR EDWARD DYER to pardon and dispense with all forfeitures and abuses by tanners under the statute of 1563. No period was assigned to the duration of this patent. It became a very unpopular grant, but although contrary perhaps to the common law, it seems in some degree to have been necessary for the protection of the tanner from the unwise rigour with which some ancient processes in tanning were enforced on the manufacturer. The penalties dispensed with and of course compounded for, would appear now in the light of permissions to use an improved process.

Letters patent issued to **Cornelius de Vos**, a Dutchman, for making "allom and copperas." A Bill passed the House of Commons confirming this grant, which it appears De Vos had assigned to Lord Montjoye: for several reasons it may be considered one of the most important of the age. Alum was used in great quantities by dyers, to whom it was essential, and its price was very high. The method of preparing it had been introduced into several places in Italy about one hundred years before this, and into some places in the dominions of the Pope; but his Holiness understood his own interest so well, that he never rested until he had caused all the works in the territories of his neighbours to be abandoned, and he alone remained master of the prize. He then endeavoured to prevent foreigners acquiring a knowledge of the art of boiling alum; entered into treaties with other nations to supply them with it; and to increase his trade, he gave out that he meant to devote the profits to the defence of Christianity, and carrying on the war against the Turks; if any one was so unchristian as to buy alum from the Spaniards, who had small quantities to dispose of, or from the Turks or Genoese, who had some alum works near Smyrna, he was admonished and threatened and excommunicated. At this time some alum works had been erected in Germany, but they do not appear to have been prosperous, and many of them were given up. De Vos may have been from one of these manufactories. Nothing is known of his or Lord Montjoye's subsequent proceedings.

A patent granted to **William Humfreys** and **Christopher Shute**, (a German,) to dig and work all mines, minerals, except "allom and copperice," and subterranean treasures, such as gold, silver, copper, tin, lead, calaminaris, quicksilver, and all manner of ewers, simple or pure, mixt or compounded, for latten wire or steel, which should be found in England and Wales, not mentioned in the patent to Houghsetter and within the English pale in Ireland.

These patentees were also formed into a corporate company, and the property divided into thirty-eight shares, with half and quarter parts, which turned out most advantageous both for the crown and for the corporators.

The allom and copperice had been granted to Cornelius De Vos and Lord Mountjoye.

1567. Patent to **Charles Hastings**, Esq. That in consideration that he brought in the skill of making of *frisadoes* as they were made at Harlem and Amsterdam, being not used in England; that therefore he should have the sole trade of the making and selling thereof for divers years, charging all other subjects not to make frisadoes in England during that time. Hastings exhibited an information in the Exchequer against some clothiers of Coxfall for making frisadoes; "who demurred," says Noy, "that it was *against* law to have such penalties of the goods, and 100 pounds to be forfeited by *force* of a letters patent." Hastings went no further in his information, but exhibited his bill in the Exchequer against them, where, upon examination, it appeared that the same clothiers did make baize very like to Hastings' frisadoes, and that they did make them before Hastings' patent. They were neither punished nor restrained from making.

1568. Fulling mills gaining ground in spite of all attempts to repress them. It is attempted to divide the profit between the fullers by "mains et pees," and the mills. The Act directs that no cap shall be thicked or fulled in any mill until it has been first well scoured and closed on the bank, and half footed at least on the foot-stock.

"A needle," says Fuller, "is a pin with an eye. It is woman's pencil, and embroidery is the masterpiece thereof. This industrious instrument, needle, quasi ne idle, as some will have it, maintaineth many millions; yea, he who desireth a blessing on the plough and the needle, comprehends most employments at home and abroad, by land and by sea."

"In Queen Marie's dayes," according to Stowe, "there was a negro made manie fyne Spanish needles in Chepeside, but would never teache his art to anie." "Such was the negro's envy," adds Fuller. "The making of Spanish needles," continues Stowe, "was first taughte in England by Elias Crowse, a Germaine, about the eighte yeere of Queen Elizabeth." "He was more charitable," says Fuller again, "and since then we have taught ourselves the using of them."

Richard Dyer, according to Howes, "after he had beene manie yeares in Spaine, where hee learnede the arte of making earthen furnaces, earthen fier-pots, and earthen ovens, transportable, taught his countrey the making of the same at London without Moregate, and for a tyme enjoyed the whole profit to himself by patent."

1569. "William Rider," says Stowe, "neare the foot of London Bridge, seeing a pair of knit worsted stockings in the hands of an Italian merchant, which came from Mantua, borrowed them for a time, and caused others to be made like them. These were the first worsted stockings made (in that particular way) in England. Being approved by commoners, the sale became great, and in a short time the kingdom was well supplied with them. At their first appearance even nobles used to wear them. The Earl of Pembroke is stated to be the first nobleman that ever wore any worsted stockings in England." For this mark of infinite attention to his own comfort, the historian might have added that he will be, perhaps, the only earl of his family whom posterity will know anything about. Rider, most probably, introduced some improvement. Knit stockings were common in England at least fifty years before.

Like many other communities that of Norwich was as thankless as it was unjust. In 1570 a conspiracy was formed by some Norfolk gentlemen and others against the industrious and wealth-bringing Walloons and Dutchmen, whose numbers had greatly augmented. The plot was disclosed by Thomas Ket, one of the conspirators, and John Throgmorton, described as a gentleman, and a man of substance, was arrested with many others, the greater number of whom were persons in easy circumstances. Ten were indicted for treason, others for minor offences, and many were condemned. Throgmorton, with a generous concern for his companions in offence which was worthy a better cause, in order to avert the threatened indiscriminate severities, admitted that he was the chief and active instigator of the conspiracy. He was one of the three on whom death was inflicted. The intentions of the conspirators were to have raised forces at Harlestone fair, and out of Bungay and Beccles, "and so to have beene at Norwiche in such a sodeyne as at the mayres feaste to have taken the whole cupboorde of plate to have maynteyned the enterpryse," and then by "sound of trumpet and beat of drum to have declared the cause of their rising, and to expulse the strangers from the city and realm." But as God, says an historian, shortened some of their days, their purposes were defeated, and the hated strangers found favour, and were continued in their trades, by which they got much riches, but nevertheless they gave much work and abundance to the poor around them.

The fate of Throgmorton and his associates was not calculated to mend the social position of the Flemings. Many citizens were their enemies from their connexion with those who had broken the law, and other influential citizens going with the stream, in appearance added to the numbers of the hostile party. They insisted on regulating the industry of the Flemings by "new ordinances and hard commons," such as to sell none of their commodities but to freemen of the city, and such like. The strangers applied to the queen in council for protection. Elizabeth issued a letter to the corporation, minding them that "the poor men of the Dutch nation fleeing the persecution lately begun in their countrey for the new religion, who hath fledd into this realm for succour, inhabited their empty houses, employed a number of people who were hitherto idle, and consumed a great deal of provisions."

The appeal and this letter still further incensed the townsmen against the Flemings. They were persecuted for complaining of persecution, and the citizens on some pretences shut up their hall. Elizabeth again interposed, and they were relieved for a time from municipal oppression.

In a return made to the Privy Council in 1571, there were, in Norwich alone—men of the Dutch nation, 868; men of the Walloon nation, 203; women of both nations, 1173; and children under fourteen years of age, 1681; in all 3925 souls. Ten years afterwards this community had increased to 1128 men, 1358 women, 815 children stranger born, 1378 children English born, in all 4679 souls; and it is stated in the same return that 653 persons paid £293 a year for rent.

1571. Caps were the ancient general and profitable covering of men's heads in this island, and it is worth our pains to observe the tenderness of our kings to preserve the trade of cap making, and what long and strong struggles, says Fuller, our state had to keep up the using thereof; so many thousands of people (eight thousand in London, and probably twice as many in other parts of the kingdom) being maintained thereby, especially before the invention of fulling mills. All caps before that time being wrought, beaten, and thickened by the hands and feet of men, till those mills as they eased many of their labour ousted more of their livelihood. Capping anciently set fifteen different callings at work; corders, spinners, knitters, parters of wool, forcers, thickers, dressers, walkers, dyers, battelers, shearers, pressers, edgers, liners, bandmakers, and other exercises. No wonder then if so many as six statutes were made to encourage the handicraft. First in 1483, by Edward IV., that none were to thicken caps at the fulling mill under a penalty; in 1512, by Henry VIII., prohibiting importation of caps; another in 1530, by the same king, that foreign caps should be sold at a low price to prevent merchants importing them; then in 1554, by Edward VI. reviving the prohibition and penalty of the Act of Edward IV.; in 1568, by Queen Elizabeth dividing the profit with the mills, and lastly by the same queen in this year, 1571, passing an Act, that caps were to be worn by *all* persons (some of quality and worship excepted) on sabbaths and holidays.

But it seems nothing but hats would suit the heads and the humour of the English, who fancied them better adapted than caps to fence their fair faces from the injury of wind and weather.

The best caps were made at Monmouth, but on the occasion of a great plague about fifty years after this, the trade was removed to Beaudly in Worcestershire; but the article retained the name of "Monmouth cap."

The power of the sovereign to grant rights and privileges to inventors and others by letters patent became again the subject of discussion in Parliament.

During a debate on a subsidy to the queen, Mr. Bell, a lawyer, alluded to the hardship imposed on the people by grants of letters patent to do certain matters contrary to the statutes, "by which," he said, "a few only were enriched, and the multitude impoverished;" and he added, "that if a burden should be laid on the Commons' back, and no redress of the common evils, then there might happily ensue that they would lay down the burden in the midst of the way, and turn to the contrary of their duty."

Mr. Godier, on the contrary, thought "that the subsidy should go forth without the hearing of any more complaints, for which he gave the notable reason, "that the complaints might be infinite, and already more were remembered than in one Parliament could be reformed." Sergeant Lovelace said, every subject ought to yield to the relief of the prince, and that without any condition or limitation; but he thought it very requisite that the evils also should be provided for: so orderly did Mr. Bell utter what he spake, that although those who were touched might be angry, but justly to blame him might not be, says the reporter, yet it gave great offence to the queen, who "sent a commandment to the speaker to spend little time in motions and to avoid long speeches. Bell was had before the Privy Council, and so hardly dealt with, says Wentworth, that he came into the House with such an amazed countenance, that it daunted them all in such sort, that for several days there was not one of the members durst deal in any matter of importance, and in those simple matters that they dealt in, they spent more words and time in their preamble requiring that they might not be mistaken, than they did in the matter they spoke unto; whereupon this rumour grew in the House:—Sirs, you may not speak against the licences, the queen's majesty will be angry. The council too will be angry!"

Next day there was a sharp contest on a bill brought in for the dissolution of a company of merchants in Bristol, whom her Majesty had authorized by letters patent to trade to certain places, by which it was considered the public and free trading of others was restrained. The renowned Sebastian Cabot was the first governor of this company. Mr. Fleetwood showed, that "the prerogative might be touched if they should endeavour to overthrow her Majesty's patent in this case, and she is sworn to preserve her prerogative." But the member for Bristol, Mr. Young, urged "the loss of the queen's custom, and the controversies which have arisen among the citizens themselves through this monopoly." Mr. Alford "might not speak of the prerogative aptly, for that he was not learned in the law; but made some remembrance of what he had there seen concerning the bill for Southampton, where it appeared that without an Act of Parliament her Majesty's letters patent were not sufficient."

The Court was embarrassed by these discussions, and to check them resorted to a manœuvre. A member not connected with the government was to state what might be the result of a real attack on the queen's irregular proceedings. The tool used was Sir Humphrey Gilbert, who made occasion a few days after to prove, that Mr. Bell's motion "was a vain device to be thought of, and perilous to be treated of, since it tended to the derogation of the prerogative imperial, which he who would attempt in his fancy could not otherwise be accounted than as an open enemy; for what difference is it to say the queen is not to use the privilege of the crown, and to say she is not queen, since they are so linked together, that one without the other may not possibly be or subsist. We are to give to a common constable the right and regard of his office, which if we should deny her, what is it other than to make her meaner than the meanest? And albeit experience hath showed such and so great clemency in her Majesty as might make us perhaps perfect ourselves, yet it is not good to sport or venture too much with princes. If we should in any sort meddle with those matters, her Majesty might look to her own power, and thereby finding her validity to suppress the strength of the challenged liberty, and to use her power any way, to do as did Lewis of France, who, as he termed it, delivered the crown there out of wardship upon a like occasion. Other kings had absolute power. Where as the crown became more free (limited) so are all the subjects thereby the rather made slaves."

This extraordinary speech was disliked, says the reporter, as implying many occasions of mischief, and was not answered further than to show Sir Humphrey, that he had mistaken Mr. Bell's meaning. However, the sturdy Peter Wentworth, member for Tregony, in course of a debate, took an opportunity to remember the oration of Sir Humphrey, delivered a week before. "He proved the knight's speech (without naming him) to be an injury to the House, he noted the knight's disposition to flatter and fawn on the prince, comparing him to the cameleon, which can change himself into all colours saving white, even so, this knight could change himself into all fashions *but* honesty. He showed the great wrong done to one in the House, (Mr. Bell,) by a misreport made to the queen; he showed that the knight's speech tended to no other end than to inculcate fear into those who should be free. He requested care for the credit of the House and for the maintenance of free speech, the only means of ordinary proceedings, and to preserve the liberties of the House to reprove liars, inveighing greatly out of the scriptures and otherwise against liars; as this of David, 'Thou, O Lord, shalt destroy liars.'" The Speaker endeavoured an "agreement and unity in the House, by stating, that so far from the queen being offended she had declared unto him that she had good intelligence of the orderly proceedings among us, whereof she had as good liking as ever she had of any Parliament since she came to the crown, and wished we should give her no other cause than to continue the same; and that her Majesty's pleasure further was to take order for licences, (letters patent,) wherein she had been careful, and more careful would be."

Notwithstanding this courteous assurance, delivered by the proper authority, yet at the dissolution of Parliament a month afterwards, her Majesty being seated in her royal seat, the chancellor, Sir Nicholas Bacon, in her presence, and at her desire, replied thus to the Speaker's oration:—"For the better signification of what her Majesty's opinion is both of parliament men and parliament matters, this is to let you understand that her Majesty hath commanded me to say unto you, that like as the greatest number of the Lower House have in the proceedings of this sessions showed themselves modest, discreet and dutiful, as becomes good and loving subjects, and meet for the places that they be called unto; so there be certain of them, though not many in number, who have showed themselves audacious, arrogant, and presumptuous, calling her Majesty's grants and prerogatives into question, contrary to their duty and place that they be called unto, and contrary to the express admonition given in her Majesty's name in the beginning of this Parliament, which it might very well become them to have regard unto. But her Majesty saith, that seeing they will thus wilfully forget themselves, they are otherwise to be remembered; and like as her Majesty allows and much commends the former sort for the respects aforesaid, so doth her Highness utterly disallow and condemn the second sort, for their audacious, arrogant, and presumptuous folly, thus by superfluous speech spending much time in meddling with matters neither pertaining to them nor within the compass of their understanding."

1573. John Tice attained to the perfection of making all sorts of tufted taffaties, cloth of tissue, wrought velvets, branched satins, and other kinds of curious silk stuffs.

1574. Began making steele poking sticks. "Until now all laundresses," says Stowe, "used setting sticks made of wood or bone."

Salt rose from three shillings to six shillings a bushel, the like never had been seen in England before. The scarcity of wood was depressing this manufacture like that of iron.

1575. A patent to Robert Sharp to make spangles and oes of gold. The wire, it is supposed, was first twisted round a rod into the form of a screw, and then cut into single spiral rings, and these were placed on a smooth anvil and flattened by the blow of a hammer. A small hole was thus left in the middle of them, and the ends of the wire united. They are supposed to have been made in the French gold and silver manufactories a little after this time. Sharp may have been the inventor, or improver of the art.

Bombasins first made at Norwich in this year.

Patent to **Tallis** and **Bird** to print their "Cantiones." Neither of the patentees were printers, they received the patent from the queen for printing music only. It was the first of its kind. The improvement in the musical type they used is ascribed to Thomas Vantrollier (or Vautrowllier) of the Black Friars, the printer of the Cantiones for the patentees.

The music printers succeeding Vantrollier were Thomas d'Este, who changed his name to Snodham, John Windel, William Barley, and others. These men followed the practice of the foreign printers, but made no improvement in the art.

1576. From the excessive price of leather its exportation is again prohibited; tallow and raw hides are also not to be sent out of the country. Yet wrought leather articles, or even tanned leather, are not allowed to be imported.

Manufacture of watches brought into England by some Germans.

1578. At the pageant exhibited to Queen Elizabeth at Norwich, the following variety of looms were "pourtrayed:" loom for worsteds, for russets, for darnix, for mockado, for lace, for caffa, and for fringe; and upon the stage at one end stood eight small women children spinning worsted yarn, and at the other end many knitting of worsted hose.

1579. Morgan Hubblethorne, a dyer, was sent to Persia to learn the art of making and dyeing carpets. Hackluyt directs him to obtain some other information:—"There are," he says, "persons there who stain linen cloth. It hath been an old trade in England, whereof some excellent cloths yet remain, although the art be now lost in this country."

1580. Men now began to engage in the manufacture of silk, which hitherto had been wholly done by women.

"Of later times Thames water was conveyed into men's houses by pipes of lead from a most artificial force standinge neare to London Bridge, and made by Peter Morice, a Dutchman, in the yeare 1582, for the service of the citie." This was enlarged, and in 1683, Stowe says, "Morice in this gave assurance of his skill in raising the Thames water so high as should supply the upper part of London. For the mayor and aldermen came down to observe the experiment, and they saw him throw the water down over St. Magnus' steeple, before which time no such thing was known in England as this raising of water. It was done by a mill." A water-wheel, placed in an arch of the bridge, gave motion to a forcing pump. This use of the forcing pump was at least eighty years before the invention of the fire-engine in which it was introduced to act in the same way.

Naipery, or table-linen, was in general use among persons even in humble circumstances. It was imported. The finest came from French Flanders, and was high priced. In Ben Jonson's "Silent Woman," Mrs. Otter mentions her table-cloth which cost eighteen pounds.

The machine for cutting clock wheels introduced; that for cutting watch wheels also appeared about this time, and are said to be English contrivances.

English horn ware in great estimation in foreign countries, and exported largely.

BOURAS makes the first engine for scale boards (?).

1581. The Act against using logwood, or blackwood, as a deceitful stuff in dyeing, directs that "nothing in the nature of cloth shall be henceforth mathered for black, except it be first grounded with woad only, or with woad and anele, alias blue inde, unlesse the madder be put in with a shoomake or galles."

Wax exported in considerable quantities, and melters were forbidden to use any deceit in mixing it with rosin, tallow, or turpentine, or other deceitful stuff, particularly for what is used in lights, staff-torches, red wax, or sealing wax, book candle, searing of dead corps, links, or green wax.

The scarcity of wood for fuel particularly so great that it was enacted that no iron works should be erected within 22 miles of London, nor should any wood within 14 miles of the Thames be converted to cole or fuel for the making of iron.

1585. It was attempted to prevent sumach being used in dyeing, but the bill was rejected by the House as a "frivolous bill."

Any new iron work not to be erected in Kent, Surrey, or Sussex, on account of the destruction of the wood, and increasing scarcity of fuel.

Devon and Cornwall woollen weavers could not legally employ more than three looms, each for making "white straits."

1586. One Ross made the first bandore in England, which was long afterwards called the Ross-viol.

1587. In the instructions given to choose an harquebuss, "a Myllan peece," or barrel, is to be preferred, because "they bee of a toughe and perfect temper, lighte, square and bigge of breeche, and very strong where the powder doth lie, and where the violent force of the fier doth consiste, and notwithstanding thin at the end. Our Englishe peeces approach very neer unto them in goodnesse and beautie, their heavinesse only excepted, so that they bee made of purpose, and not one of these sale peeces with round barrels." This is great praise, for Milan was at this time, and had been for centuries, renowned for the excellency of its arms and armour of all sorts.

1588. Letters patent to REYNOLD HEXTON to make flaskes, locke boxes, powder-boxes, and bullet boxes, for fifteen years.

Patent.—To SIR WALTER RALEIGH to grant licences for keeping of taverns.

Patent.—To SIR WALTER RALEIGH to dig for tin in Cornwall.

1589 Patent.—To JOHN ASHLEY and THOMAS WYNDEBANK to have the benefit of forfeitures and fines for burning timber-trees, contrary to statute. This patent had a similar object to that granted to Sir Edward Dyer. It was to enable the iron masters to smelt in the counties adjacent to London, by compounding for the penalties of cutting down wood for that purpose

Patent to transport listes and shreds of woollen cloth, and horns. SIMON FARMER and JOHN CRAFFORD, 21 years.

Patent to SIR JEROME BOWES to make glass for 12 years.

In the petition of the frame-work knitters to Oliver Cromwell, they give the following account of the invention of the stocking frame:—"The trade of frame-work knitting was never known nor practised, either here in England, nor in any other place in the world, before it was invented and found out by one William Lee, of Calverton, gent., who, by himself, and such of his kindred and countrymen as he took unto him for servants, practised the same many years past, somewhat imperfectly in comparison of the exactness it is sithence brought unto by the endeavours of some of these petitioners. Yet even in the infancy thereof it gathered sufficient estimation of a business of so extraordinary national profit and advantage as to be invited over into France, upon allurements of great rewards, privileges and honour, not long before the sudden murther of the late King Henry IV.; unsuccessfully accepted by Mr. Lee, at that time wanting due encouragement at home; and transporting himself with nine workmen, his servants, (with some frames,) unto Roan, there wrought to so great applause of the French, that the trade was in all likelihood to have been settled in that country for ever, had not the decease of the said king disappointed Mr. Lee of his expected grant of privileges, and the succeeding troubles of that kingdom delayed his renewed suit to that purpose into discontentment and death, at Paris; leaving his workmen at Roan to provide for themselves, several of which returned back into England with their frames, and here practised and improved their trade, under whom, or the master workmen since risen, the petitioners had their breeding. Of the other two left in France, one only is yet surviving, but so far short of the perfection of his trade, as it is used here, that of him, or what can be done by him, or of his means, these petitioners are in no apprehension or fear, nor have not been since then endangered in foreign countries by any that have served their full time of apprenticeship here.

"But near about that time a Venetian ambassador gave £500 for a remnant of time of one Henry Mead, then an apprentice to this trade, and conveyed him, with his frame, from London to Venice, where, though his work, and the manner of it, was for awhile admired and endeavoured to be imitated, yet, as soon as necessity of reparation of his frame and instruments happened, for want of artificers experienced in such work there, and of ability in him to direct them, the work prospered not in his managing; so that his bought time of service being expired, affection to his native country brought him home again into England. After his departure the Venetians grew disheartened; and impatient of making vain trials, they sent their disordered frame and some of their own imitations to be sold in London at a very low valuation.

"And within a few years the trade was greatly endangered by one Abraham Jones, who having by underhand courses and insinuations, and not by servitude as an apprentice, gotten both the mystery and skilful practice there of, did, contrary to the articles of the rest of the company that had taken such zealous notice of him, pass himself with some more into Amsterdam, and there taking some Dutch unto him as servants, erected frames and wrought for two or three years, until the infection of the plague seized on him and his whole family, and carried them all to the grave. His frames also, as things unprofitable to them who could not find out their right use, without any able master, were sent to London and sold at slight rates."

To this statement of the stocking-weavers, Deering adds, that "Lee was a Master of Arts of St. John's College, Cambridge, and born at Woodborough, a village about seven miles from Nottingham, and that he was heir to a pretty freehold estate. The traditional story says, that he was deeply in love with a young woman, whom he courted to be his wife, but whenever he went to visit her she always seemed more mindful of her knitting than of the addresses of her sweetheart. This slighting conduct gave Mr. Lee such an aversion to knitting that he determined to invent a machine that should henceforth make knitting such an useless employment, that no courted woman should have the least excuse for not listening to the flattering tales of her admirer. He brought his design to bear about 1589. After he had worked awhile he taught his brother and several relations to work under him; and having practised this art at Calverton, a village five miles from Nottingham, either himself or his brother worked before Queen Elizabeth to show an experiment, offering at the same time this discovery to his countrymen, who, instead of accepting the offer, despised him; and being discountenanced at home, he accepted King Henry's invitation. One of Mr. Lee's apprentices, named Aston, did not accompany him into France, but became a miller at Thornton, near which he was born. Aston added something to his master's invention."

The next grand invention of this period is the gun wheel lock, first used at the siege of Parma, in 1521, which was defended by the Marquis de Foix. It made slow progress, however, for it was not used before 1586 in Germany. "It was," says Meyrick, "a contrivance for exciting sparks of fire by the friction of a furrowed wheel of steel at the bottom of the pan, which, with a quick revolution, grated against a piece of pyrites. The spring which turned this wheel was wound up, or as the term was, spanned with a small lever termed a spanner. When this instrument was put on the projecting axle of the wheel, which was made square, and fitted with a corresponding hole at one end of it, the spanner was turned from right to left, which made the wheel instantly revolve, and by this movement a little slider which covered the pan containing the priming retired from over it. The spanner was then removed, and the cock, like that in the modern firelocks, containing the pyrites was brought down upon the wheel; it being placed, contrary to the modern fashion, beyond the pan. The trigger being pulled as in ordinary pistols, the wheel revolved, and grating against the pyrites produced the fire and communicated to the priming. In an ancient specimen the iron of the barrel is $\frac{1}{8}$ inch thick, and the butt has a spheroidal knob at the end. The length of the pistol is $20\frac{1}{2}$ inches, with a long iron hook by which it could be held in the girdle."

An Act passed to prevent wine casks being exported, because the timber of the realm was greatly damaged and decayed, and its want was feared; and a great deal of it was converted into cloven board for making of casks, which are usually transported out of the realm, whereas wine casks which are imported are very serviceable for many purposes; therefore in future, for every six tuns of beer transported, two hundred weight of clapboards, each three feet two inches long, or a new cask, was to be imported within four months after sailing; and if the beer was sent to Ireland the same quantity of shafford board was to be introduced.

At this time it appears to have been the practice for foreign dealers to send their own casks to the English brewer to be filled, for another Act says, "When any Scottish man, or other stranger, shall bring from beyond seas to the brewer any manner of foreign cask to have beer put into it, it need not be gauged."

1590. The ladies invented the large hoop farthingales. Those who could not purchase them, "provided for themselves," says Strutt, "the bumrolls which they put up under their petticoats to make them stick out.

"I was a ladye," says Chloe, "before I debased myself from my hood and farthingale to these bum rowles and your *whalebone* boddice." The materials of the boddice indicate the manufacture of another material. The *rowles* have again been adopted, (1845,) and so well is the art of stuffing understood that even girls when bussled might be mistaken for full grown Hottentot Venuses.

Godfrey Box, of Liege, erected at Dartford the first iron mill for slitting bars.

Patent, to import steel and sell it in the realm, to Bryan Annersley for 21 years.

1591. Patent, to receive fees for filing bills in Chancery. John Parker.

The cloth called mildernix or powledavies, of which the sailcloth for the navy was made, before this time was "altogether brought out of France and other parts beyond sea, and the skill and art of weaving the clothes was never known or used in England, until about this year, when perfect art was attained thereto."

1592. Basket-hilted swords appear to have originated among the Scots, to supply the place of a gauntlet, which had been often made by wrapping the bonnet or end of the cloak or plaid round the right arm.

1593. Sir John Fortescue, during a debate on a subsidy, said that, Queen Elizabeth "hath with her ships compassed the whole world, whereby the island is made famous throughout all places. She did find in her navy all *iron* pieces, but she hath furnished it with artillery of brass, so that one of her ships is not a subject's but a petty king's wealth." Some of these were captures.

1594. Patent to import all Spanish wool for the making of felt hats, to Michael Stanhope, for 20 years.

Patent to import aniseeds and sumacke. Robert Alexander, 21 years.

Patent to receive forfeitures, on statute of 1553, for pulling down Grig mills. Roger Byneon.

1595. Patent to receive penalties on statute for gashing of hides and barking trees. William Smith.

1596. Patent "to trade to the Levant for corants only, and to pay 4,000 pounds per annum." W. Mercer.

Patent to license gaming houses to Thomas Cornwallis.

1597. Armour now largely manufactured. A bill brought into the House to prohibit the importation of foreign armour was rejected.

The promise the Queen made to Parliament twenty-six years ago, that in future she would be more careful in her concessions of letters patent, was kept for a time with good faith. During the bygone eleven years, however, various grants had been made to individuals about the court, which were felt to be not only injurious but against the law. In numerous cases they were rendered still more unpopular and odious by the arbitrary proceedings of the agents of those to whom the monopolies had been granted.

During a debate in Parliament on the hardship of persons being obliged to keep various sorts of arms and weapons in their possession, which the change of circumstances had rendered useless, Mr. Moore made some allusions to the more oppressive evil—that of grants of letters patent.

Next day the subject was resumed by Mr. Wingfield, of Peterborough, who succeeded in a motion to nominate a committee to inquire into the matter.

After various sharp skirmishes the committee recommended that at the close of the session, which was then near at hand, the Speaker should state to her Majesty, as a part of his customary address, a "set and penned speech made at the committee, and which was agreed to by the House."

On the last day of the session, after the Speaker, Yelverton, made his formal oration to the Queen, she called, says the reporter, "Sir Thomas Egerton, the Lord Keeper, who was standing beside her, to whom, kneeling down before her, she spake in private; and so after Sir Thomas went into a place like a desk, and there made answer to the Speaker's speech, saying, 'Touching the monopolies, her Majesty hoped that her dutiful and loving subjects would not take away her prerogative, which is the chiefest flower in her garden, and the principal and head pearl in her crown and diadem, but that they will rather leave that to her disposition; and as her Majesty hath proceeded to *tryal* of them *already*, so she promiseth to continue that they shall all be examined to abide the trial and true touchstone of the law.'"

Patent to buy linen rags, and make paper, to John Spelman, for 14 years.

Patent to grant licenses to brew beer for exportation, to William Carre.

Patent to make starch and ashes, and to import them. Sir John Packington.

1598. Patent to transport "ashes and ould shoes," to Edward Schetts. 7 years.

Patent to import and make cards. Edward Darcy.

Patent to export ordnance. Sir Henry Neville.

Patent to license persons to buy tin throughout England. Richard Conisby.

Millers had not yet began to make flour; they merely ground the corn, and the bakers and farmers sifted the meal in their own houses by sieves, or latterly by hand bolting mills.

Some time after this sundry rich millers caused bolting mills to be set up, moved by horses, others by hand, and lastly by wind or water. When poor people brought their wheat to be ground, and required these millers to bolt it, they had the bran for their trouble.

Of ancient European arms and armour, the most beautiful were those from Italy and Spain, next those from Germany and Flanders. The French excel the English. The forms were nearly alike; the fashions took their rise from Italy. Most of the splendid suits seem to have been procured from Milan, or Nuremburg on the Maine, and Heilbronn on the Necker, where there were celebrated manufactories.

1599. Patent to have the pre-emption of tin. Brigham and Wynnes.

Patent to have an "imposicion of seacoles paying 6,200 livs. rent," to Bevis Bulmer, 21 years.

Patent for stone pots and bottles, to Sir Henry Noel.

Patent to bring in Irish yarn. Richard Carmarthen, 7 years.

Patent for tanning. James Chambers.

Patent for aquavitæ. Richard Drake.

A patent with ampler powers than contained in former one granted to Thomas Morley for printing music. After the expiration of this patent the art was common to printers in general.

1600. Patent to make saltpetre. John Harding.

Patent to make sulphur, brimstone, and oil. William Wade, Esq.

Patent to make mathematical instruments. J. Davies.

Patent to planish and hollow silver vessels. William Haddon and others.

Patent to inne and drayne grounds.

Patent to take water fowle.

Patent. Devises for safe keeping of corne.

Patent. Devises for soldiers to carry necessary provisions.

Patent to sow woad in certain shires.

Patent to sow 600 acres of woad or oade, to Valentine Harris.

Patent to make writs of subpœna in Chancery. Sir Thomas Gorge.

Patent to write certain writs. George Carew.

Patent to draw leases in reversion made by the king. Sir Edward Stafford.

Patent to register all writings and assurances between merchants.

Patent to transport sheep and lamb skins.

Patent to transport woollen cloth.

Patent to transport calf skins. Arthur Bassary.

Patents to print:—
  Psalms of David.
  Cornelius Tacitus. Richard Welsh.
  Almanacs. William Watkin, James Roberts.
  Speculum Britanniæ. John Norden.
  School Books. Sir Henry Singer.
  Law Books. Thomas Wight, Bonam Norton*.

1601. At the opening of Parliament in October, the Queen told the Speaker that this would be a short Parliament, and she "willed that the members should not spend time in frivolous, vain, and unnecessary motions and arguments;" and a few days afterwards Secretary Cecil, in imitation of his mistress, "wished that they would not trouble themselves with any fantastic speeches or idle bills, but rather with such as be for the general good, both light in conception and facile in execution."

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* The foregoing list was drawn up chiefly from a memorandum by the Earl of Shrewsbury, then in office, and endorsed "25 Mai, 1603.—Note of Monopolies," granted between 1588 and 1601. Nearly the whole of those of which the dates are wanting were issued between the time when the Queen promised, in

About the middle of the session, after a small tumult had been allayed that had been occasioned by a bailiff arresting the valet of one of the members, the Speaker gave the clerk a bill to read, on which the members called for another bill, and some said "Yea," and some said "No," and a great noise there was, says the reporter, when MR. LAWRENCE HIDE, rising, said, "Mr. Speaker, to end this controversy, because the time is very short, I would move the House to have a very short bill read, entitled 'An Act for the explanation of the Common Law in certain cases of Letters Patent.'" All the House cried "Aye," "Aye." After being read, the question was put for its commitment, and some cried "Commit it," some cried "Engross it," when MR. SPICER, of Warwick, stood up and said, "This assembly may be said to be *libera mens et libera lingua*, therefore freely and faithfully that which I know I will speak; this bill may touch the prerogative royal, which, as I learned last Parliament, is so transcendent, that the wishes of the subject may not aspire thereunto; far be it therefore from me that the state and prerogative royal of the prince should be tied by me, or by the act of any other subject. First, let us consider of the word *monopoly*, what it is; *monos* is *unus*, and *polis* is *civitas*, so that the meaning of the word is, a restraint of anything public in a city or commonwealth to a private use, and the user called a *monopolitan, quasi cujus privatim lucrum est urbis et orbis commune malum;* and we may well term this man the whirlpool of the prince's profit. Every man hath three special friends, his goods, his kinsfolks, and his good name: these men may have the two first but not the last; they are *insidiosa quia dulcia*, they are *dolosa quia dubia*. I speak not either repining at her Majesty's prerogatives, or misliking the reasons of her grants, but out of grief of heart, to see the town wherein I serve pestered and continually vext by the substitutes and vicegerents of these monopolitans, who are ever ill disposed and affected members, which I beseech you give me leave to prove unto you by this argument. Whosoever transgresseth the royal commission of her Majesty, being granted upon good and warrantable suggestions, and also abuseth the authority and warrant of her Majesty's privy council for the more favourable execution of his patent, this man is an evil-disposed and dangerous subject. And

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1597, to take order for them in future, and the debate in 1601. Another list, drawn up by Mr. Wingfield, the "crying member," and handed about among the members during the debate, was read by Sir Robert Wroth, in course of his speech.

that this is true, and hath been done by one person, a substitute of a patentee, I will thus prove to you.

"The substitutes for aquavitæ and vinegar came not long since to the town where I serve, and presently stayed sale of both these commodities; unless the sellers would compound with them they must presently to the council table. Myself, though ignorant, yet not so unskilful, because of my profession, but that I could judge whether their proceedings were according to their authority, viewed their patent, and found they exceeded in three points; for where the patent gives six months liberty to the subject that hath any aquavitæ to sell the same, this person comes down within two months, and takes bond of them to his own use, where he ought to bring them before a justice of the peace, and they there to be bound in recognizance, and after to be returned into the Exchequer, and so by usurpation retaineth power in his own hands to kill or save; moreover this substitute stands indicted as an obstinate recusant; yea, when her Majesty's name hath been spoken of and herself prayed for, he hath refused to stir hat or lip."

Mr. Francis Bacon, Attorney-general, said, "I confess the bill, as it is, is in few words, but yet ponderous and weighty. For the prerogative royal of the prince, for my own part I ever allowed of it; and it is such as I hope shall never be discussed. The Queen as she is our sovereign, hath an enlarging and restraining power, for by her prerogative she may set at liberty things restrained by statute law or otherwise; and secondly, by her prerogative she may restrain things which be at liberty. For the first, she may grant *non obstante* contrary to the penal laws, which truly according to my own conscience, (and so struck himself on the breast,) are as hateful to the subject as monopolies. For second, if any man out of his own wit, industry, or endeavour, finds out any thing beneficial for the commonwealth, or bring in any new invention which every subject of this kingdom may use, yet in regard to his pains and travail therein her Majesty is perhaps pleased to grant him a privilege to use the same only by himself, or his deputies, for a certain time. This is one kind of monopoly. Sometimes there is a glut of things when they be in excessive quantity, as perhaps of corn; and her Majesty gives license of transportation to one man,—this is another kind of monopoly. Sometimes there is a scarcity, or a small quantity, and the like is granted to bring in. These and divers of this nature, have been in trial at the Common Pleas upon actions of trespass, where if the judges do find the privilege good and beneficial to the commonwealth they then will allow it—otherwise disallow it. Also I know, that her Majesty herself hath given commandment to her Attorney-general to bring divers of them since the last Parliament to trial in the Exchequer, since which time at least fifteen or sixteen to my knowledge have been repealed, some by her Majesty's own express commandment upon complaint made unto her by petition, and some by *quo warranto* in the Exchequer." "But, Mr. Speaker," continued Bacon, pointing to the bill, "this is no stranger to this place, but a stranger in this vestment. The use hath ever been to humble ourselves unto her Majesty, and by *petition* desire to have our grievances remedied, especially when the remedy toucheth her so nigh in the point of prerogative. All cannot be done at once, neither was it possible since the last Parliament to repeal all. If her Majesty make a patent, or, as we term it, a monopoly, unto any of her servants, that must go, and we cry out of it; but if she grant it to a number of burgesses or a corporation, that must stand, and that forsooth is no monopoly. I say, and I say again, that we ought not to deal, to judge, or meddle with her Majesty's prerogative. I wish every man therefore to be careful in this business. And humbly pray this House to testifie with me, that I have discharged my duty in respect of my place in speaking on her Majesty's behalf, and protest I have delivered my conscience in saying that which I have said."

DR. BENNET.—"He that will go about to debate her Majesty's prerogative royal had need walk warily. In respect of a grievance out of the city, for which I come, I think myself bound to speak that now which I had not intended to speak before; I mean a monopoly of salt. It is an old proverb, *sal sapet omnia*, fire and water are not more necessary; but for other monopolies, (at which words Sir Walter Raleigh blushed,) of cards, dice, starch, and the like, they are, because monopolies, I must confess, very hurtful, though not all alike hurtful; and I think if the abuses in this monopoly of salt were particularized this would walk in the fore rank. Now since we are come to the means of redress, let us see that it be so mannerly and handsomely handled, that after a commitment it may have a good passage."

MR. LAWRENCE HIDE.—"I confess, Mr. Speaker, that I owe duty to God and loyalty to my prince. For the bill itself, I made it, and I think I understand it. And far be it from this heart of mine to think, this tongue to speak, or this hand to write, any thing either in prejudice or derogation of her Majesty's prerogative royal and the state. But, because you shall know that this course is no new invention, but long since digested in the age of our forefathers above three hundred years ago, I will offer to your considerations one precedent in the tenth year of King Edward the Third, at what time one John Peach was arraigned at this bar in Parliament for that he had obtained of the king a monopoly for sweet wines. The patent, after great advice and dispute, was adjudged void, and before his face and in open Parliament cancelled, because he had exacted three shillings and fourpence for every tun of wine; himself adjudged to prison until he had made restitution of all that ever he had recovered, and not to be delivered until after a fine of 500*l.* paid to the king. This is a precedent worthy of observation, but I dare not presume to say worthy the following; and as I think it no derogation to the majesty of God to say he can do all but evil, so I think it no derogation to the majesty or person of the Queen to say the like in some proportion. Yet, because two eyes may see more than one, I pray, Mr. Speaker, that there may be a commitment had of this bill, lest something may be therein which may be taken hold of by some of the monopolists. They bring the general profit into a private hand, and the end of all is beggary and bondage to the subjects. We have a law for the true and faithful currying of leather. There is a patent sets all that at liberty notwithstanding that statute; and to what purpose is it to do any thing by Act of Parliament when the Queen will undo the same by her prerogative? Out of the spirit of humiliation I do speak it, there is no act of hers that hath been or is more derogatory to the commonwealth than the granting of these monopolies."

Mr. Martin.—I speak for a town that grieves and pines, for a country that groaneth and languisheth under the burden of monstrous and unconscionable subsidies to the patentees of starch, tinn, fish, cloth, oyl, vinegar, salt, and I know not what, nay what not. These monopolists may prove the bane and overthrow of the bill at the time of the passing.

Sergeant Harris.—The House moveth to have the bill in the nature of a petition, it must then begin with more humiliation. Truly it is good of itself, but the penning of it is somewhat out of course.

Mr. Montague.—The matter is good and honest; and I like this manner of proceeding by bill well enough, and I would note only unto you thus much, that the last Parliament we proceeded by way of petition, which had no successful effect.

Mr. Moore.—I know the Queen's prerogative is a thing curious to be dealt withal, yet all grievances are not comparable. I cannot utter with my tongue or conceive with my heart the great grievances that the town and country for which I serve suffer—its commodities are engrossed into the hands of these bloodsuckers of the commonwealth. If they be still let alone to suck up the best and principalest commodities which the earth there has given us, what shall become of us when the fruits of our own soil and the commodities of our own labour, which with the sweat of our brows, even up to the knees in mire and dirt, we have laboured for, shall be taken by warrant of supreme authority, which the poor subjects dare not gainsay.

Sir George Moore.—I make no question but this bill offereth good matter. Many grievances have been laid open touching the monopolies of salt, but if we add thereunto *peter*, then we have the grief aright with which my country is perplexed.

There be three persons, her Majesty, the patentee, and the subject; her Majesty the head, the patentee the hand, and the subject the foot. Now here is our case,—the head gives power to the hands, the hand oppresseth the foot, the foot riseth against the head; we know the power of her Majesty cannot be restrained by any Act: why therefore should we thus talk?—admit we should make this statute with a non obstante, yet the Queen may grant a patent with a non obstante to cross this non obstante. I think therefore it agreeth more with the wisdom and gravity of this House to proceed with all humbleness by petition than by bill.

MR. WINGFIELD.—I would but put the House in mind of the proceeding we had in this matter last Parliament, in the end whereof our Speaker moved her Majesty by way of petition, that the grievances coming of the monopolies might be redressed. Her Majesty answered by the Lord Keeper, that she would take care of these monopolies, and our griefs should be redressed; if not, she would give us free liberty to proceed in making a law the next Parliament. The grief is still bleeding, and we groan under the sore, and are still without remedy. It was my hap last Parliament to encounter with the word prerogative; but as then, so now I do it with all humility, and wish all happiness both unto it and to her Majesty. I am indifferent touching our proceedings, either by bill or petition, so that therein her Majesty may specially understand our grievances.

SIR WALTER RALEIGH.—I am urged to speak in two respects. One, because I find self touched in particular, the other in that I take some imputation of slander to be offered unto her Majesty. I mean by the gentleman that first mentioned tin, for that being one of the principal commodities of this kingdom, and being in Cornwall, it hath ever so long as there were any belonged to the dukes of Cornwall, and they had special patents of privilege. It pleased her Majesty freely to bestow on me that privilege, and that patent being word for word the very same as the duke's is. And because by reason of mine office of Lord Warden of the Stannary I can sufficiently inform this House of the state thereof, I will make bold to deliver it unto you. When the tin is taken out of the mine, and melted and refined, then is every piece containing one hundredweight sealed with the duke's seal; now I will tell you that before the granting of my patent, whether tin were but of seventeen shillings, and so upward to fifty shillings a hundred, yet the poor workmen never had above two shillings in the week, finding themselves; but since my patent, whosoever will work, may; and buy tin at what price soever, they have four shillings a week truly paid; there is no poor that will work there but may and have that wages. Notwithstanding, if all others may be repealed, I will give my consent as freely to the cancelling of this as any member of this House.

A great silence followed this speech of Sir Walter's; for the House noted his imputation of slander on the Queen, when SIR FRANCIS HASTINGS rose and said:—"It is a special honour to this House to give freedom of speech to all, and howsoever some have been heretofore troubled, yet I joy to see so great reformation that we may speak quietly and be heard peaceably. Every man hath not like sense or judgment, neither is every man's memory alike, and I wish that if any gentleman that speaks of this or any other subject as injurious shall let fall any word amiss or unpleasing, that it may be attributed rather to hastiness than want of duty."

"If we proceed by way of petition," said MR. DOWNLAND, "we can have no more gracious answer than we had last Parliament; but since that Parliament we have no reformation, and the reason why I think no reformation hath been had is because I never heard the cry against monopolies greater and more vehement."

MR. JOHNSON.—I'll be very short, Mr. Speaker, and say only thus much; I would we were all so happy that her gracious self had heard but the fifth part of that every one of us hath heard this day. I think really in my soul and conscience we should not be more desirous in having these monopolies called in, than she would be earnest therein herself.

The debate was resumed on the following day, by

SIR EDWARD HOBBIE.—"Betwixt Michaelmas and St. Andrew's tide, when salt before the patent was wont to be sold for sixteen pence a bushel, it was sold for fourteen or fifteen shillings; but after the Lord President had understanding of this, he imprisioned the patentee, and caused the salt to be sold for sixteen pence as before. To Lyme there is annually brought above 3,000 wey of salt, and every wey since the patent enhanced to twenty shillings. I dare boldly say it, that in white salt 3,000*l.* a year might be saved in the ports of Lyme, Boston, and Hull."

MR. FRANCIS BACON.—"The bill is very injurious and ridiculous,—injurious in that it taketh, or rather sweepeth away, her Majesty's prerogative; and ridiculous in that there is a proviso that this statute shall not extend to grants made to corporations. That is a gull to sweeten the bill withal. All men of the law know that a bill which is only expository to expound the common law doth enact nothing; neither is any promise of good therein. I think this bill very unfit, and our proceedings ought to be by petition."

MR. FLEMING, Solicitor-General.—Last Hilary term her Majesty gave charge to me and Mr. Francis Bacon to take speedy and special order for these patents, but that nothing could be done for want of leisure.

SIR ROBERT WROTH.—"I will but note that you were charged in last Hilary term. Why not before? There was time enough ever since the last Parliament (dissolved nearly four years before). I speak it, and I speak it boldly—these patentees are worse than ever they were. There have been divers patents granted *since* the last Parliament. Those are now in being, to wit, the patents for currants, iron, powder, cards, ox-shin bones, trayn oil, transportation of leather, lists of cloth, ashes, anniseeds, vinegar, sea-coles, steel, aquavitæ, brushes, pots, saltpetre, lead, accidences, oyle, calamin, stone, oyl of blubber, fumathoes, or dried pilchards in the smoke, and others." On naming which, MR. HACKWELL, of Lincoln's Inn, asked, "Is not bread there?" "Bread!" quoth one. "Bread!" quoth a second. "This voice seems strange," quoth a third. "No," quoth Mr. Hackwell, "if order be not taken for these now, bread *will* be there before the next Parliament."

Seeing the House could agree upon nothing, MR. TOWNSEND, a lawyer, said, "Notwithstanding the result of the last Parliament, I think the House would succeed better on the present occasion. I propose to send the Speaker to the Queen, with the humble suit of the House to repeal all patents grievous to the subject, and to obtain her leave that they might be of no more force or validity than they are at the common law, without the strength of her prerogative.—And that every member of the House may put in fair writing such exceptions against monopolies as he would justifie to be true; and that the Speaker should deliver them with his own hands to her Majesty."

MR. FRANCIS BACON again spoke against proceeding by bill, and concluded by saying:—"Why you have the readiest course that possibly can be devised. I would wish no farther order to be taken, but to prefer the wise and discreet speech made by the young gentleman, (even the youngest in this assembly,) that last spake. I will tell you that even *ex ore infantium et lactantium*, the true and most certain course is propounded to us."

MR. SPICER.—I am no apostate, I still stick to my former faith and opinion. It is to no purpose to tie her hands by an Act of Parliament, where she may loosen herself at her pleasure,—it were a course *nec gratum nec tutum;* by way of petition will be our safest course.

MR. DAVIES.—God hath given that power to absolute princes which he attributed to himself, *dixi quod dii estis*, and as attributes unto them he hath given majesty, justice, and mercy. Majesty, in respect of the honour that the subject showeth to a prince; justice, in respect that he can do no wrong—therefore the law is that the king cannot commit a disseisin; mercy, in respect he giveth leave to subjects to right themselves by law. And on these accounts, I think it most fit to proceed by bill.

This brought Secretary CECIL again forward.—"Had there not been," says he, "some mistaking in the committee, I would not now have spoken. The question was, of the most convenient way to reform these grievances of monopoly; but after disputation, of the labour we have not received the expected fruit. If every man shall take leave to speak for the common subject, I am afraid we shall dispute the project and reformation quite out of doors. This dispute draws two great things in question; first, the prince's power; second, the freedom of Englishmen. I am born an Englishman, and am a fellow member of this House. I would desire to live no day in which I should detract from either. I am a servant unto the Queen, and before I would speak or give consent to a case that should debase her prerogative, or abridge it, I would wish my tongue cut out of my head. I am sure there were law makers before there were laws. One gentleman went about to possess us with the execution of the law in an ancient record, at the time of Edward III., likely enough to be true of that time, when the king was afraid of the subject. Though this precedent be a substance, yet it is not the whole, for in former times all sat together, as well king as subject, and then it was no prejudice to his prerogative to have such monopoly examined. If you stand upon law, and dispute of the prerogative, hear ye what Bracton saith, '*Prærogativam nostram nemo audeat disputare.*' I had rather all the patents were destroyed than her Majesty should lose the hearts of so many of her subjects as was pretended. I will tell you what I think of these monopolies; I take them to be of three natures; some of a free nature and good; some void of themselves; some both good and void. For first, when the prince dispenses with a penal law that is left to the alteration of sovereignty, I think it powerful and irrevocable: for the second, as to grant that which taketh from the subject his birthright, such men as desire these kind of patents, I account them misdoers and wilful and wicked offenders: of the third sort is the licence for cards, &c. I think, therefore, it were fit to have a new committee, and to consider what her Majesty may grant, what not,—what course we shall take, and on what points; and you, Mr. Speaker, should perform the charge her Majesty gave unto you in the beginning of this Parliament, not to receive bills of this nature; for her Majesty's ears be open to all grievances, and her hand stretcht out to every man's petition."

Mr. Montague.—"I am loth to speak of what I know, lest, perhaps, I should displease. The prerogative royal, now in question, the laws of the land have ever allowed and maintained. My motion shall be but this—that we be suitors unto her Majesty, that the patentees shall have no other remedies than by the laws of the land they may have, and that our Act may be accordingly."

Upon some loud confusion in the House on the following day, concerning the murmuring which had taken place in public against monopolies, Secretary Cecil said:—"The duty I owe, and zeal to extinguish monopolies, and to satisfy their opinions that think that there shall be no redress of these monopolies, makes me speak now. Order is attended with these two handmaids, gravity and zeal, but zeal with discretion. I have been, though unworthy, a member of this House in six or seven Parliaments, yet never did I see the House in so great confusion. I believe there never was in any Parliament a more tender point handled than the liberty of the subject. But that when any is discussing this point he should be cried and coughed down, this is more fit for a grammar school than a Court of Parliament. I have been a councillor of state these twelve years, yet did I never know it subject to construction of levity and disorder. Much more ought we to be regardful in so great and grave an assembly. Why, we have had speeches upon speeches without either order or discretion. One would have had us proceed by bill, and see if the Queen would have denied it; and another, that the patents should be brought here before us and cancelled, and this were bravely done; others would have us to proceed by way of petition. For the first, and especially for the second, it is so ridiculous that I think we should have had as bad success as the devil himself would have wished in so good a cause. Why, if idle courses had been followed, we should have gone, forsooth, to the Queen with a petition to have repealed a monopoly of tobacco pipes, and I know not how many conceits; but I wish every man to rest satisfied till the committee brings in its resolution."

Next day, after some ordinary business had been concluded, a scene new in a Tudor Parliament was presented. After a considerable silence, and all marvelling why he stood up so composedly, the Speaker said, "It pleased her Majesty to command me to attend upon her yesterday in the afternoon, from whom I am to deliver unto you all her most gracious message. She yields you all hearty thanks for your care and special regard of those things that concern her state, kingdom, and consequently ourselves, whose good she had always tendered as our own. It pleased her Majesty to say unto me that, if she had an hundred tongues she could not express our hearty goodwills. She appealed to the throne of Almighty God, how careful she hath been, and will be, to defend her people from oppressions, and that the least of her subjects was not grieved and she not touched. She said that, partly by intimation of her council, and partly by divers petitions that have been delivered to her, both going to the chapel, and also to walk abroad, she understood that divers patents that she had granted were grievous to her subjects, and that the substitutes of the patentees had used great oppressions; but she said, she never assented to grant anything which was *malum in se;* and if in the abuse of her grant there be anything evil, which she took notice there was, she herself would take present order of reformation. I cannot express to you the apparent indignation of her Majesty towards these abuses. She said that her *kingly* prerogative, so she termed it, was tender, and therefore desired us not to fear or doubt of her reformation; for she said her commandment had been given before the late troubles; and in the middest of her most grave and weighty occasions she thought upon them. That this should not suffice, but that further order should be taken presently, and not in *futuro*—for that was, also, another word her Majesty used; and that some should be presently suspended, and some repealed, and none put in execution but such as should first have a trial according to the law for the good of the people. Now, as we see that the axe of her princely justice is laid to the root of the tree, so we see her gracious goodness hath prevented our counsels and consultations. God make us thankful, and send her long to reign among us."

After a little pause, and silent talking one with another, Secretary CECIL said:—

"I was present with the rest of my fellow counsellors, and the message is the same that hath been told you; and the cause hath not succeeded (with the Queen) from any particular course thought upon, but from private information her Majesty had from some particular persons. There are no patents now of force which shall not presently be revoked; for what patent soever is granted there shall be left to the overthrow of that patent a liberty agreeable to the law. There is no patent, if it be *malum in se*, for the Queen was ill apprized in her grant; but all to the generality be unacceptable. I take it there is no patent that hath not in the execution been injurious; would that they had never been granted; I hope there shall never be any more. (Here all the House said Amen.) In particular, most of these patents have been supported by letters of assistance from the Privy Council, but whosoever looks upon them shall find that they carry no other stile than with relation to the patent. I dare assure you that from henceforth there shall no more be granted. They shall all be revoked. But to whom do the patentees repair with these letters? To some outhouse, to some desolate widow, to some simple cottage, or poor ignorant people, who rather than they will be troubled and undo themselves by coming up hither, will give anything in reason for these caterpillars' satisfaction. You will perhaps judge this to be a tale to serve the time; but I would have all men know this much, that it is no jesting with a Court of Parliament, neither dares any man, for my own part I dare not, so mock and abuse all the states of this kingdom in a matter of this consequence and importance. I say, therefore, there shall be a proclamation general throughout the realm, to notify her Majesty's resolution in this behalf.

"And, because you may eat your meat more savourly than you have done, every man shall have salt as good cheap as he can either buy it or make it, without danger of that patent which shall be speedily revoked. The same benefit shall they have which have cold stomachs for aquavitæ and the like; and they that have weak stomachs, for their satisfaction shall have vinegar and alegar and the like set at liberty. Train oil shall go the same way. Oil of blubber shall march in equal rank. Brushes and bottles endure the like judgment. The patent for pouldavies, if it be not called in, shall be. Oade, which as I take it is not restrained either by law or statute, but only by proclamation, I mean from the farmer sowing it, (though for the saving thereof it might admit good disputation;) yet for your satisfaction the Queen's pleasure is to revoke that proclamation; only she prayeth thus much, that when she cometh on progress to see you in your countries, she be not driven out of your towns by suffering it to infect the air too near them. Those that desire to go sprucely in their ruffs may at less charge than accustomed obtain their wish, for the patent for starch, which hath so much been prosecuted, shall now be repealed. There are other patents which be considerable, as the patent of new drapery, which shall be suspended and left to the law. Irish yarn, a matter that I am sorry there is no cause of complaint, for the salvageness of the people, and the war, hath frustrated the hope of the patentee, Mr. Carmarthen, a gentleman of good service and desert, a good subject to her Majesty, and a good member of the commonwealth. Notwithstanding, it shall be suspended and left to the law. The patent for calf-skins and fells, which was made with a relation, shall endure the censure of the law. But I must tell you there is no reason that all shall be revoked, for the Queen means not to be swept out of her prerogative; I say it shall be suspended if the law do not warrant it. There is another gentleman, Mr. Onslow, one of her pensioners, an honest gentleman, and a faithful servant; he hath the patent for steel which one Mr. Beale once had; this, too, because of complaints, shall be suspended. There is another that hath the patent for leather, Sir Edward Dyer, a gentleman of good desert, honest, religious and wise; this was granted unto him thirty years ago; it crept not in by the new misgovernment of the time,—yet this also shall be suspended. The patent for cards shall be suspended and tryable by the common law. The patent for glasses, which though I do least apprehend to be prejudicial to the public good, yet it is left to the law. There is another patent for saltpetre, that hath been both accused and slandered; it digs in every man's house, it annoys the inhabitant, and generally troubleth the subject; for this I beseech you be contented; yet I know I am to blame to desire it, it being condemned by you in *foro conscientiæ*, but I assure you it shall be fully sifted and tried in *foro judicii*. Her Majesty means to take this patent unto herself, and advise with her council touching the same; for I must tell you the kingdom is not so well furnished with powder now as it should be; but if it be thought fit upon advice to be cancelled, her Majesty commanded me to tell you, that though she be willing to help the grave gentleman that hath that patent, yet out of that abundant desire she hath to give you complete satisfaction it shall be repealed. As a counsellor of state, I have done my best to salve the sore, but I fear we are not secret within ourselves; then must I needs give you this for a future caution, that whatsoever is subject to public expectation cannot be good while the parliament matters are ordinary talk in the street. I have heard myself, being in my coach, these words spoken aloud, 'God prosper those that farther the overthrow of these monopolies;' 'God send the prerogative touch not our liberties.' I will not wrong any one so much as to imagine he was of this assembly. Yet, let me give you this note, that the time was never more apt to disorder and make ill interpretation of good meaning; I think those persons would be glad that all sovereignty were converted into popularity. We being here are but the popular branch, and our liberty, the liberty of the subject; and the world is apt to slander, most especially, the ministers of government.

"Thus much I have spoken to accomplish my duty to her Majesty. I must crave your favours a little longer to make an apology for myself. I have held the favour of this House as dear as my life, and I have been told that I deserved to be taxed yesterday of the House. I protest my zeal to have the business go forward in a right and hopeful course, and my fear to displease her Majesty by a harsh and rash proceeding, made me so much to lay aside my discretion that I said, that it might rather be termed a school than a council, or to that effect. But, by this speech, if any think that I called him 'schoolboy,' he both wrongs me and mistakes me. Shall I tell you what Demosthenes said to the clamours which the Athenians made, that they were *pueriles et dignos pueris*, and yet that was to a popular state. I wish that whatsoever is here spoken may be buried within these walls: let us take example of the Jewish synagogue, who would always *sepelire senatum cum honore*, and not blast their own follies and imperfections. If any man in this House speak wisely, we do him great wrong to interrupt him,—if foolishly, let us hear him out, we shall have the more cause to tax him; and I do heartily pray that no member may *plus verbis offendere quàm consilio juvare*."

Mr. Francis Moore.—I moved the House, both the last Parliament and this, touching this point; but I never meant, and I hope this House thinketh so, to set limits and bounds to the prerogative royal; but now, since it hath pleased her Majesty of herself, and out of the abundance of her princely goodness, to set at liberty her subjects from the thraldom of these monopolies, from which there was no town, city, or country free—I would be bold in one motion, to offer two considerations to this House: first, that the Speaker might go unto her Majesty, to yield her most humble and hearty thanks, and withal to show the joy and the thankfulness of her subjects for their delivery. The other, that where divers speeches have been made extravagantly, which doubtless have been told to her Majesty, and ill conceived of by her, that Mr. Speaker not only should satisfy her Majesty by way of apology therein, but also humbly crave pardon for the same.

"My heart," said Mr. Wingfield, "is not able to conceive the joy I feel, and I assure you my tongue cannot utter the same. If a sentence of everlasting happiness had been pronounced to me, it could not have made me show more outward joy than I now do, which I cannot refrain to express; (and here, says the reporter, as I think, he *wept!*) and verily I think if any of her Majesty's words be meritorious before God, this is. I do agree with all my heart in the first part of the gentleman's motion, but do utterly dislike the latter, for it is not to be intended that we should have had so good and gracious a message if the truth of some particular speeches had been delivered unto her; and now for us to accuse ourselves, by excusing a fault with which we are not charged, were a thing, in my opinion, inconvenient, and unfitting the wisdom of this House."

The House thereupon concluded that their thanks only should be returned to her Majesty by the Speaker.

Some of the more active members, at the head almost of whom was the "weeper," seem to have been not only surprised, but somewhat frightened at their own success. Notwithstanding the Queen's frank and unconditional surrender of the illegal claim, there seems to have been a strong impression that the present concession, which she had refused on former occasions, was some convenient expedient to allay a present irritation. The same insincerity might be shown after this declaration as followed the promise of reformation to the last Parliament. Accordingly, Mr. Downald at the next sitting moved that, "the gracious message which had been sent from her Majesty might be *written* in the books of record of this House, being worthy to be written in gold as well as written and fixed in the true heart of every good subject; and that the House would move her Majesty to make earnest means of speed, lest that which is now meant indeed, may, by protraction of time, be altered, or perhaps not so happily effected."

Secretary Cecil said, "I promised to be as silent as I could. Among much speech of the wise there wants not much folly, much more in me. I do not speak because I do dislike the motion, but to defend the diligence and grace of the Queen. Though the idol of a monopoly be a great monster, yet after two or three days I doubt not but you shall see him dismembered. I protest there is not any soul that lives that deserves thanks in this cause but our sovereign. Yesterday the Queen gave order for a draught of a proclamation. I had it in my hand. You all know I went even now out of the House—then I read it—and sent for him that should deliver it to her hands. Now what needs this new zeal?

Mr. Davies said, "It is not much I had to say,—only this: that which was delivered from her sacred self, I think to be gospel, that is, 'glad tidings;' and as the gospel is *registered* and *written*, so would I have that also, for if ever glad tidings came to the heart of the subject they now come. This is all, Mr. Speaker."

Sir George Moore.—"This eating and fretting disease of monopolies I ever detested with my heart, and the greater the grievance is the more inestimable is the grave wisdom of her Majesty in repealing them; and therefore for us to think we can sufficiently requite the same, it were to hold a candle before the sun to dim its light. Seeing she in her clemency and care hath taken the matter in her own hands, I wish the matter may be no more spoken of, much less proceeded in."

Mr. Lawrence Hide.—"The gentleman that set this motion on foot, spoke out of joy for her Majesty's grace and zeal to have performance of her promise, in that he wished it might be recorded in paper here or parchment; he intended, and meant also in our hearts, which remain no longer than we live; but *records* remain long, and will give a lively memory in ages to come, and therefore I wish the clerk may do it accordingly."

Mr. Comptroller.—The mover of the question exceedingly forgot himself, and exceedingly detracted from her Majesty, who, I know, out of her abundant love and grace, hath taken such speedy course as hath been delivered by Mr. Secretary. With that affection she embraceth this House,—that in more familiar than princely sort it hath pleased her to say, "Recommend me to the House, with thanks for their promise, and care of the public good."

"My heart," said the Speaker, "is not able to conceive, nor my tongue to utter the joy I conceived of her Majesty's gracious and especial care for our good. Wherefore, as God himself said, '*gloriam meam alteri non dabo*,' so may her Majesty say, in that she herself will be her only and speedy agent for performance of our humble and most wished for desires. Wherefore let us not doubt, but as she hath been so she will still be our most gracious sovereign and natural nursing mother unto us, whose days the Almighty God prolong to all our comforts."

All the House said Amen.

On the following day, the Speaker, Croke, accompanied by some sevenscore members of the Parliament, proceeded to audience of her Majesty, who received them in the council-chamber at Whitehall. After three low reverences, the Speaker said, "Most sacred and most gracious Sovereign, your faithful, loyal, and obedient subjects and commons here present, vouchsafed of your especial goodness to our unspeakable comfort access to your sacred presence, do in all duty and humbleness come to present that which no words can express, most humble and thankful acknowledgment of your most gracious message, and most bounden and humble thanks for your Majesty's most abundant goodness extended and performed to us. We cannot say, most gracious Sovereign, we have called and been heard, we have complained and have been helped, though in all duty and thankfulness we acknowledge your sacred ears are ever open, are ever bowed down to hear us, and your blessed hands ever stretched out to relieve us. We acknowledge, sacred Sovereign, in all duty and thankfulness we acknowledge, that before we call, your preventing grace and all deserving goodness doth watch over us for our good, more ready to give than we can desire, much less deserve. That attribute which is most proper unto God, to perform all he promiseth, appertaineth also unto you, our most gracious Sovereign, queen of all truth, of all constancy, of all goodness, never wearied in doing good unto us, the deeds themselves do speak, most careful to provide all good things for us, most gracious, most tender to remove all grievances, which all your princely actions have ever showed, and even now your most gracious *published proclamation*, of your own only mere motion and special grace for the good of all your people, doth witness unto us. We come not, sacred Sovereign, one of ten to render thanks and the rest to go away unthankful, but all of us in all duty and thankfulness do throw down ourselves at the feet of your Majesty, do praise God, and bless your Majesty; neither do we present our thanks in words or any outward thing, which can be no sufficient retribution for so great goodness, but in all duty and thankfulness, prostrate at your feet, we present our most loyal and thankful hearts, even the last drop of blood in our hearts, and the last spirit of breath in our nostrils to be poured out, to be breathed up for your safety."

Having thus spoken, the sycophant made three low reverences and then knelt down, and the members who formed his train imitated his posture. The queen then said to the prostrates:—"We have heard your declaration, and perceive your care of our state by falling into the consideration of a grateful acknowledgment of such benefits as you have received, and that your coming is to present thanks unto us, which I accept with no less joy than your loves can have desire to after such a present. I do assure you there is no prince that loveth his subjects better, or whose love can countervail our love. There is no jewel, be it of never so rich a price, which I prefer before this jewel, I mean your love; for I do more esteem it than any treasure or riches, for that we know how to prize, but love and thanks I count inestimable. And though God has raised me high, I do not so much rejoice that God hath made me to be a queen over so thankful a people. And as I am that person still yet under God who hath delivered you, so I trust, by the almighty power of God, that I shall still be his instrument to preserve you from every peril, dishonour, shame, tyranny and oppression. Of myself I must needs say this, I never was any greedy, scraping grasper, nor a strait, fast-holding prince, nor yet a waster; my heart was never set on worldly goods, but only for my subjects' good. What you do bestow on me I will not hoard it up, but receive it to bestow on you again. Therefore render unto them from me, I beseech you, Mr. Speaker, such thanks as you imagine my heart yieldeth but my tongue cannot express."

All this while these sevenscore and one English gentlemen were on their bended knees, listening to her aged majesty's self-laudation, when she stopped her speech for a moment, and said, " Mr. Speaker, I would wish you and the rest to stand up, for I shall yet trouble you with a longer speech." So they all stood up as they were bid, and her Majesty continued her oration.

" You give me thanks, but I doubt me I have more cause to thank you all than you me; for had I not received a knowledge from you, I might have fallen into the lap of error only for lack of true information. Since I was queen yet still did I never put my pen to any grant but that upon pretext and semblance made unto me, that it was both good and beneficial to the subjects in general, though a private profit to some of my ancient servants who had deserved well; but the contrary being found by experience, I am exceeding beholding to such subjects, as would move the same at first. And I am not so simple to suppose, but that there be some of the Lower House whom these grievances never touched, and for them, I think they speak out of zeal to their countries, and not out of spleen or malevolent affection as being parties grieved, and I take it exceeding grateful from them, because it gives us to know that no respects or interests had moved them, other than the minds they bear to suffer no diminution of our honour and our subjects' love unto us, the zeal of which affection tending to ease my people and knit their hearts unto me, I embrace with a princely care. That my grants should be grievous to my people, and oppressions to be privileged under colour of our patents, our kingly dignity shall not suffer it. Yea, when I heard it I could give no rest to my thoughts until I had reformed it. Shall they think to escape unpunished that have thus oppressed you, and have been respectless of their duty and regardless of our honour? No, I assure you, were it not more for convenience sake than for any glory or increase of love that I desire, these errors, troubles, vexations and oppressions done by these varlets and lewd persons not worthy the name of subjects, should not escape without condign punishment. If my kingly bounty have been abused, and my grants turned to the hurt of my people contrary to my will and meaning, or if any in authority under me have neglected or perverted what I have committed to them, I hope God will not lay their culps and offences to my charge, and though there were danger in repealing our grants, yet, what danger would not I rather incur for your good than I would suffer them still to continue? To be a king and wear a crown, is more glorious to them that see it, than it is pleasure to them that wear it. For myself, I was never so much enticed with the glorious name of a king, or royal authority of a queen, as delighted that God had made me his instrument to maintain his truth and glory, and to defend this kingdom, as I said, from peril, dishonour, tyranny and oppression. Should I ascribe any thing to myself, and my sexly weakness, I were not worthy to live then, and of all most unworthy of the mercies I have had from God, who hath ever yet given me a heart which never yet feared foreign or home enemies. I speak it to give God the praise as a testimony before you, and not to attribute anything unto myself. For I, O Lord, what am I, whom practices and perils past should not fear! O! what can I do (here she spake, says the historian, with a great emphasis), that I should speak for any glory? God forbid. This, Mr. Speaker, I pray you deliver unto the House, to whom heartily recommend me. And so I commend you all to your best fortunes and further councels."

Having thus spoken she turned to some standing near her, and said, "I pray you, Mr. Comptroller, Mr. Secretary, and you of my council, that before these gentlemen depart into their countries you bring them *all* to kiss my hand."

A few days before the dissolution of Parliament a bill was read, which proposed that every one who could invent any art or trade which was good and profitable to the commonwealth, should monopolize the same to his own use during his life; and also that he that added to or refined an art or trade should have the like. The member for London objected to the bill because it was too general, and spoke of arts invented as well as to be invented, and whether the arts were beneficial or no to the commonwealth. "Many arts," he observed, "had been devised in London to do that by one man which would not heretofore be done with forty, which was unprofitable, because it did not set the poor and many hands at work—besides, it would breed confusion, because, if but a little addition be made by another, a new privilege is granted for that—and if on that another improvement is made, a licence will be granted for that, and so on."

Another member took a different view of the matter. He observed that, "This description of patent had been recognized and allowed by the present Parliament on the motion of Sir Walter Raleigh, to enable some one to make tin by mills out of the old rubbish in Cornwall; besides, it is reason that he that hath invented any art or trade should have some privilege, because it would be an encouragement to others, *nemo nascitur artifex*. No man would come to that perfection upon the first knowledge of it as if he were taught by the first inventor for a season. It did not hold in all arts that it is unprofitable that the work of many should be done by one, for it is profitable for the commonwealth that water should be brought to every man's house at 10 shillings cost, as by the water-work device in London, where it could not be done formerly for 10 pounds cost. So also of shooting and charging of ordnance and fire-works and the like, and generally of all arts and trades which require judicious and skilful workmen."

This bill was rejected, seemingly from having been considered as an attempt to open some channel of monopoly under the sanction of Parliament, by those who were blinded by the queen's ambiguous message and proclamation, and thought her intention was to call in and revoke the patents. But her prerogative, far as she stretched it, could not accomplish what she was held to promise. Notwithstanding her assertion that her grants had been generally made to ancient servants for faithful service, her present and future interest was never overlooked in the transaction, and in one way or another she reaped great pecuniary benefit from all her concessions. Most of the patents had passed into the hands of traders and companies, many of whom, on the faith of the royal grants being lawful, had laid out large sums in carrying them into effect; to revoke or nullify these deeds, therefore, without making restitution of the money expended by their holders, was certainly beyond her means, and, perhaps, felt to be inconsistent with her honour; although it was observed that there would have been infinitely less moral turpitude in "fleecing" the patentees, who were accessaries and gainers by the illegal exactions, than the public on whom the extortion was practised.

That the Queen's promises were meant only to serve an occasion, was seen in the result of a measure under discussion in Parliament at the moment she was making them. At this time a great quantity of ordnance was exported under a patent granted to Sir Henry Neville. The guns were carried to countries hostile to England, and with whom war was anticipated. This unpatriotic traffic, from which the queen was drawing a large sum (£3,000 a year) under the patent, gave great offence to the country, and was so strongly reprobated in Parliament as one signally adverse to the national interest, that a bill was brought in to prohibit its continuance.

Sir Edward Hobbie said, the bill was excellent, the matter foul, the request and remedy good and honest, but for us now to enter again on bringing or allowing acts against monopolies is to refuse her Majesty's gracious favour, and to cleave to our own affections.

Mr. Fettiplace, the member for London, said, "I know her Majesty received yearly by custom three thousand pounds for the transportation of these ordnance. It is now grown so common that if you would send merchandize beyond seas in stranger bottoms they would not carry it unless you will ballast their ships, and load them with some ordnance. Four kinds of these ordnance were now usually transported; the first, a falkon of the least weight and bore; the second, a minion, a little heavier and bigger; the third, a sacre, somewhat greater; and the fourth, a demi-culverin, being the greatest;—if it be a falkon, she shall have the weight of a minion; and so if a sacre, the weight of a demi-culverin, because when they are brought beyond the seas they will new bore them to a greater size; and eight ton of iron ordnance will make five ton of good iron. They have so much iron in Spain out of England that they do ordinarily sell a hundred weight of iron ordnance for 7½ duckets. If the queen would forbid the transportation of ordnance but for seven years, it would breed such a scarcity to the Spaniard, that we might have him even where we would. Some, no doubt, the sea would devour; some would be taken, and the store which he now hath, scattered and destroyed;—and if the Spaniard do make it a capital matter but to transport a horse or a gennet, much more ought we to have a special care herein, when we shall arm even our own enemies against ourselves; but to proceed by bill would savour of curbing the prerogative."

Sir Walter Raleigh.—"I am sure heretofore one ship of her Majesty's was able to beat ten Spaniards, but now, by reason of our own ordnance, we are hardly matcht one to one; but we should proceed by way of petition."

Mr. Carey said, "When any great or weighty matter or bill is here handled, we straight say it toucheth the prerogative, and must not be meddled withal, and so we that come to do our countries good bereave them of that good help we may justly administer."

Mr. Hackwell.—"If this transportation be necessary to aid allies and retain their alliance, I answer that it is the covetousness of our friends, who finding the inestimable gain and treasure they have by the ordnance brought from us, desire them not only for profit, but to gain to themselves confederates, by which means succouring our friends we aid our enemies. Our ordnance, this precious jewel of our realm, was as familiarly sold in the countries of confederates as any thing within this land; but being stopt they must fain to take supplies from their ports to their ships, and from their ships to the field."

Mr. Comptroler.—"We must note that her Majesty, like her progenitors, will not be forced, and we shall sooner obtain our desire by petition than by bill."

Mr. Hyde.—"Her Majesty is not more careful and watchful of her prerogatives than the noble princes of famous memory, Henry VIII. her father, and King Edward VI. her brother, were; then there was no doubt or mention of the prerogative. Our surest and soundest course is by bill."

The bill was manœuvred out of the House, on the plea of its being an encroachment on the prerogative, and that the queen was pledged to reform the patents generally. The House, having its doubts of the royal sincerity, directed Croke, the Speaker, to "say something thereof" to the queen, in the usual official speech that he would make to her Majesty next day at the close of the session; "which notice, we," said a member, "desire the more earnestly, because our bill is fallen into an everlasting sleep, and we have no remedy now but by her Majesty."

On the following day, when the members had assembled to accompany the Speaker to the House of Lords, Croke said, "If it please you, on the motion made yesterday, I mean to say something therein both for your satisfaction and for the performance of my duty, and therefore this matter need be no further moved;" with which assurance the House rested well satisfied, and followed their mouth-piece into the royal presence. But the utter sycophant broke his official confidence, and "said *not one word* in his speech to the queen touching that matter, which was greatly murmured at and spoken against amongst the burgesses, that the House should be so abused, and that nothing was done therein."

The Lord Keeper, who was standing at the queen's elbow during the Speaker's address, at her desire thus replied to him:—"I will deliver her Majesty's command with what brevity I may. First, she saith, that touching your proceedings in the matter of her prerogative, she is persuaded subjects never did more dutifully, and that she understood you did but *obiter* touch her prerogative, and no otherwise but by humble petition, and therefore the thanks that a prince may give to her subjects she willingly yieldeth, but she *now* well perceiveth that private respects are masqued under public pretence."

The historian has not stated whether this ungracious qualification of the thanks and forgiveness she specially vouchsafed about three weeks before to the members who had animadverted on her mandates, prevented any of the deputation accepting the invitation to kiss her hand in token of reconciliation, before they returned into the country; but it is certain, her declarations and proclamation now appeared in their true light. She had heard public opinion loudly expressed against the monopoly patents, as they were called,—she had been openly charged in Parliament, not only with having broken her kingly promise, made three years before to reform the grants, but further, with having, in the interval, greatly aggravated the evil by issuing a number of patents creating monopolies of the most obnoxious description; she saw the bill to regulate and fetter her assumed power in these matters would be carried through the Commons against her will, and she felt the whole proceedings a stigma on her successful, and hitherto unquestioned, government; she therefore resorted to what a historian calls "one of those well-timed concessions, (or acts of duplicity,) by which skilful princes spare themselves the mortification of being overcome." Her declaration, on the word of a prince, that she had been ignorant of the injurious tendency of the patents, was necessary to uphold the state delusion, that she neither sanctioned nor shared the plunder; and her assertion that Parliament questioned her prerogative by *petition* only, was a sacrifice of truth to her self-love and pride, not inconsistent with her habits of insincerity, though hardly to be noticed as a speck in her vigorous and glorious reign. Her proclamation removed no abuse; and as she did not live to convoke another Parliament, the "prerogative royal" was left undefined, which helped to render her successor unpopular, and was the remote cause of his son's losing his head.

CHAPTER II.

In the list of patents drawn out by Queen Elizabeth's last parliament, it was stated that one had been granted to John Spilman for the manufacture of paper. This appears to have been a very meritorious project, and one to be classed among those beneficial to the public. The mill was one of the wonders of the time, and "A description and playne discourse, and the whole benefits that paper brings, with rehearsal and setting forth in verse a paper myll built neare Darthford, by Master Spilman, jeweller to the Queen's majesty," was printed. This account is interesting as furnishing some early notices of what has now become a flourishing manufacture. Master Spilman, on whom King James afterwards conferred the honour of knighthood, the poet, informs us:—

A High Germaine he is as may be proovde,
In Lyndoam Bodenze born and bred,
And for this mille may heere be truly lovde,
And praysed too for deep device of heade.
But if the hope of gain quit not the cost,
The world will judge his labour is but lost;
To hazard hap he doth commit the same,
And seems as yet to care for nought but fame.

The Dartford mill, according to the poet, was on a more extensive scale than similar establishments in foreign countries.

In other realms their milles are not in woorthe
Scarce half so good, the proofe may well be founde,
This is so fine with workmanshipe set forthe,
So surely built and planted in the grounde,
That it doth seeme a house of som estate;
A mille most rare, a worke devisde of late,
Whose goodnesse great exceedes the outward showe,
And from whose stampe shall public profit flowe.

Six hundred men are set at worke by him,
That else might starve or seeke abroade their bread,
Who now live well and goes ful brave and trim,
And who may boast they are with paper fed,
Straunge is that foode, yet straunger made the same,
Spil-man, Help-man, so rightly call the name,
For greater helpe I gesse he cannot give,
Than by his helpe to make poore folke to live.

A previous attempt to introduce the paper manufacture into England is thus noticed:—

One Thirlby went embassador farre from hence,
To Charles the Fift an emperor of great fame,
And at return did bring with him from thence
A learned man, Remigius by name,
Who Thirlby lovde, and made by his devise
A paper mill, but not so muche in price
As this that nowe neere Darthfoord standeth well,
Where Spilman may himself and household dwell.

Sir Thomas Gresham had also been an adventurer in a similar project, and it would appear with no great success on the score of profit.

One man
That had great wealth and might much treasure spare,
He with some charge a paper mill began,
And after built a stately work most rare,
The Royall Exchaunge, but got by that more gayne
Than he indeede did lose by former payne.
But neither he, nor none before his dayes,
Made paper mill that merits soe muche prayse.

Although what has been given is already a long quotation, it would be injustice to Master Spilman's mill, to omit the apt and useful application which the poet makes of its ingenious mechanism to illustrate the moral of life.

Man's secrete faultes and foule defects of minde
Must be reformed like rags in paper mill,
When hammers helpe hath chaunged his cankered kinde,
And cleaned the heart from spotes and former ill,
A second shape and forme, full fresh and newe,
He doth receive in nature, grace, and hiew,
When water streams have washed him over quite
Then man becomes like paper faire and white.

To man is mete to serve his native soyle,
When thumping world abroad hath tried him throwe,
Or heere at home his life hath 'scaped foyle,
And he thereby may showe a blotless browe.
But this must be as paper passeth mill,
Man's doubtful dayes must passe throughe perill still,
And though great blowes do beat him backe a space,
He bides the brunt to get the greater grace.

And yields to thumps and thwarts as yce to thaw,
As frost to fier will soft and gentle wax,
Or as stiff neckes will stoupe and yielde to law,
Compelled by force to yeelde, to fire like flax.
For nothing more becomes a noble minde
Than bide the blastes and puffe of every winde,
Whose bellowes blowes to hinder well wonne fame,
When *doe-well* shall in spite possess good name.

Sir Hugh Platt lived at the same time with her majesty's jeweller, and was also a mechanical projector of great merit. He had tried to work out some of his own schemes; but the speculations had brought him more credit than money, and he said that many other inventors were in the same position as himself. "But it is now high time," says Sir Hugh, "to let the world and all posteritie to understand, that if our English artists, whereof sundry in my knowledge are of such rare and singular conceite, as they were able, yea, and woulde also be found willing, if the *stipend of honour and merit* were now propounded, fully to discover a worlde of new inventions, and they would bring forth so many rich and so inestimable buds and blossoms of skill, as neither any civil policy that hath been shut up in printed books, nor any religious charity that hath been so often and so divinely sounded in al our deafe ears, could as yet produce or show any comparable effects under them.

"And because these eagles egges bee longe in hatching, and seeing dailie experience hath now assured me," continues Sir Hugh, "that so many hands make lighte worke, yet many wits for the most parte conclude nothing, I am resolved as neither expecting nor refusing any goode course that shall be offered me, bearing to entertaine the present time, not with a theoreticall wit any longer, but with a practical hande and free spirit, bee readie to maintaine the credit of my former labours, as well by the discoverie of diverse secrete and gentlemanly skils, unto such as shall repaire unto me for the same, as also by furnishing all travellers with lighte and comely garments, not as a taylor and shoemaker in the fashion, but as an artist in giving the defensative unto them against all wet and stirring weather, so as even in a slender hat, cloake, or cassock, or bases of taffeta, satten, or grogram, and other mercery stuffes, and in a swete and cleanly boot or shoe of Spanish or Bonaventer, or any other drie leather and uncorried, each gentleman may be sufficiently armed at all points, either on foote or horseback, in the greatest shower of raine that can happen. And lastly, because I have always found it in mine owne experience an easier matter to devise manie and profitable inventions, than to dispose of one of them to the goode of the author himself, and because I know there bee many gentlemen in good favour that bee always readie and willing to entertaine a good suite, I have thought it not emisse to let them understand, that I am also as yet well furnished for them, if they come in time, and whilst my small store lasteth, all which suites, as they are for the most part new and freshe from the mint, so they are by nature and qualitie either fit for a privilege or for some new officers that may undertake such services of charge as are greatlie wanted, though daily wished for in this realme and in these times. And had the author himself found any favour in his first suites he would then have conferred those secretes freely upon his countrie, which now by reason of his further charge, and greater losse of time that is irrecoverable, he is forced to offer in this kinde, neither pleasing himselfe, nor answering the worthe of those skils which he purposeth to disclose.

" First. A means to *prepare beefe*, veale, or mutton, *without any salte*, and fit to be laide up in storehouses for manie yeares, or to furnish long voyages withal.

" A *defensative* in the highest kinde of all *armour* and artillery whatsoever from rusting in seven yeares after one preparation. This is a fit secret for all her majesties armories and all the artillery of her shippes, wherein the beauty of the armour is still preserved notwithstanding his defensative upon it. It suffreth no dampe either of freshe or brackish water to prevaile against it. This is an inestimable secrete for the sea in the opinion of Sir Francis Drake.

" An excellent *caliver* or *musket shot*, exceeding all bullets that are yet had in ordinarie use. Of these the author will bee readie to make such store as shall be required.

" Some English *secretes*, whereby we may be lesse beholdinge either unto Spaine or Fraunce in some of their best commodities.

" A *candle* of much lesse price than our ordinarie candles, each of them lasting 120 howres at the least. It is sodainly made.

" A newe kinde of *malting*, wherein the halfe of our usual fyre will be saved.

" A cheape and multiplied *pitch*, serviceable only for shippes and other vessels.

" A certaine and speedie way of *thuning* of any breach.

" The art *spagirical*, which shal bee delivered in a most briefe and speedy manner for the drawing of all oiles out of gums, seeds, floweres, and aromaticall bodies, and of all water sperites, and salts out of vegetables, with all necessarie circumstances belonging thereto.

"An excellent *oiley composition*, defending all iron workes from rust and canker, wherewith I did furnish Sir Francis Drake in his last voyage.

"A *pump* not weighing 20 pound in weight, and yet sufficient to deliver 5 tuns of water in an hower. It is an excellent engine to water all those houses that are neare the river of Thames or any other river in England, as also for all shippes of warre.

"A *liquor* to keepe either boot, shoe, or buskin, made of drie leather, both blacke in wearing and defensible against all raine, dew, or moisture, whereof there hath already bin a sufficient tryal had by divers gentlemen and others. This is to be had of the author in divers kindes."

1601. There is no more instructive instance of the lengths to which trade regutions were carried than is given in the dispute between the plasterers and the painters. Under the year 1485 we have noticed the formation of the Plasterers' Company. "They were incorporated," says Sir Stephen Soame, "with right of search for their company to remedy certain abuses of lath, plaster, loam and lyme; neither in their incorporation, nor in their ordinances, is there the word *colours*. They have however been suffered to lay all house colours, as red lead and oker, with such like, but they never laid any colour upon any of the king's houses nor in the sheriff's until this year. They now intrude themselves into all colours, they not only take their own work, but leave nothing to do for the painters. Painters and stainers in the time of Edward III. were separate companies, one for painting of posts and all timber work, and the other for painting and staining of cloth of great continuance. The two companies were joined in one in the reign of Edward IV., and had orders for the use of oyls and colours. They had letters patent from Queen Elizabeth forbidding to any artificer the use of oil or size after the manner of painting, but to such as shall have been apprenticed to a painter. Painters cannot work without colours, their only mixture being oil and size, which the plasterers do now usurp and intrude into. The plasterers say the painters abridged other companies of their colours, which is manifestly untrue, for goldsmiths use colours, but not after the manner of painters, and work without oil or size. Bookbinders use colours without oil or size, cutlers use varnishing and gilding, glaziers use colours with nealing in the oven, joiners use varnish, and bricklayers use colours, but neither with oil or size. Workmanship and skill are the gift of God, and not one in ten proveth a workman, yet it is requisite that all such as have been brought up all the days of their life in a trade, and cannot attain to excellency of skill that is required, should live by the baser part of their science, which is working in oil and size those flats, posts, and windows. If plasterers be suffered to paint, no workman will keep an apprentice for five or six years to practise, and not able to get one penny towards his meat and drink in laying of oil colours on flats and posts.

"It is a curious art, and requireth a good eye and a steadfast hand, which the infirmity of age decayeth quickly, and then painters beg. Among the number of three hundred painters now in London, there are not twelve sufficient workmen to be found among them; and one of these (he being fifty years old, and such was his poverty,) was fain for his relief to wife and children to wear, upon lord mayor's day, a blue gown and red cap and carry a torch. These walls, curiously painted in former ages, the imagery so perfectly done, the arms so artificially drawn, do witness our forefathers care in cherishing this art of painting, but this is not done now; besides, painting of cloths is decayed, and not a hundred yards of new painted cloth are made here in a year, by reason of so much Flanders pieces being brought from thence, so that painters now have nothing to live on but laying of oil colours on posts and windows and flats; and one man will lay and paint more colours in a day than ten men can grind, which grinding shall be the relief of two or three hundred poor men who cannot attain workmanship, and who must go a begging with their wives and children for want of work, which is taken away by the plasterers. The painters give the plasterers six colours, commonly used with size and not with oil. Plasterers take money from the highest personages to the meanest cottager, whose walls must needs be made, but painters take money of but few for their delight; and for every twenty shillings that are earned with oil colours, ten pounds are earned with size colours, which are every man's money." For these and similar reasons the plasterers were restrained from working with oil colours.

1603. At the beginning of Queen Elizabeth's reign there were scarce a dozen of milliners' shops in London; about 1576 they began to multiply very fast, and now they abound in the streets between the city and Westminster. In these shops are to be found foreign cloths, such as Flemish kersies, frisadoes, Spanish and French gloves, highly perfumed; brooches, Italian agglets, Spanish daggers, swords, knives, and girdles, spurs, glasses, caps, painted cruses, inkhorns, penners, dials, cards, tables, balls, puppets, toothpicks, silk, and also silver bottoms, hawk's-bells, fine earthen pots, or porcelain, salt-cellars, and tin dishes and spoons, all mostly of foreign, or called, of foreign manufacture.

1604. The discussion of the grievances produced by monopolies which had embarrassed the close of the reign of Elizabeth, was again opened in the first parliament of James I., and it was resolved by the House of Commons that those who had a just cause of complaint should draw it out in writing, that it might be considered by a committee appointed for grievances, previous to the introduction of a law meet for the occasion.

The committee appear to have proceeded with some diligence, for before the end of that session, Sir Edwin Sandys presented their report on monopolies to the House. On this occasion it was stated that in general the monopoly companies were not prosperous, although they vended nearly all the commodities of the kingdom. And also that so far from free trade being in all cases an advantage to the community, said the advocates for the patentees, it was often found to be a great evil; and they referred to the liberty given in 1588 to all traders to buy cloths at Westminster, which before that could only be purchased by the company of merchant adventurers. When the trade was thrown open, the company refrained from buying, and the cloths lay on the hands of the manufacturers, many of whom were ruined, and the clothiers were finally forced to petition to have the former restraints on the trade restored! The merchant adventurers at that time, however, had the entire control of one branch of the export trade, and with this in their favour they could, and did, at their pleasure command the home market[a].

The act passed by Elizabeth in 1563 was intended to empower the justices to fix the rate of wages of labourers and workmen generally; but doubts being raised on some of its clauses, its operation was confined to the wages of agricultural labourers only. The measure, on the whole, was said to have been beneficial to the labourers, although the wages had not always been regulated and proportioned according to the "plenty, scarcity, and necessity of the times as they ought to have been." By the new law, the justices had authority not only to fix the rate of wages of agricultural labourers, but the wages of weavers, spinsters, and of all workmen whatsoever engaged by the day, month, or year. They were also empowered to fix what every person should take by the great (or piece) for mowing, reaping, and thrashing of corn, mowing and making of hay, ditching, paling, railing or hedging, by the rod, perch, lugge, yard, pole, rope, or foot, and for *every other kind* of reasonable labour and service;—and those who either gave, or received more or less than the authorized wages, were to pay a penalty of ten shillings, to be collected, if need were, by distress and sale of the offender's goods.

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[a] In the course of debate it was mentioned that the whole customs drawn from the port of London did not exceed £110,000, and from all the rest of the kingdom about £17,000, in all about £127,000 a year. At the present time the customs of the port of London bring in £11,778,000, and last year the customs of the small port of Gloucester amounted to £158,166, or £31,000 a year more than the customs of all England at the accession of James I.

Felt hats, against which so much hostility had heretofore been shown by the cappers, were now a staple manufacture. It was, however, alleged, that the hats had greatly degenerated in quality since their first introduction, which it was argued was occasioned by the working hatters not being properly trained. Many manufacturers retained a great number of hands, who went away before their time of service had expired, and being unskilful, made a large quantity of bad hats, to the great damage of the king's loving subjects who bought and wore them. The manufacture was therefore put under the corporation shackle.—No one was permitted to make felt or hat with foreign wool, who had not been an apprentice for seven years, nor any hat maker to have more than two apprentices at once.

Linen cloth also was said " to be made and weaved in likeness and show of mildernix and powle davies, of which sail cloth and other furniture for the navy and shipping are made, but in truth neither made of good and sufficient hemp, nor so well driven or weaved, nor of that length or breadth of true cloths, and do yearly grow worse and worse, and are made thinner and slighter and meaner than heretofore, through the unskilfulness, deceitfulness, and ignorance of the weavers, to the great damage of His Highnesses navy, the chiefest strength of his realm, next to God and His Highness, and within a short time like utterly to overthrow the art and trade of that kind within the realm;" and the former act was renewed, and penalties imposed, in hopes of improving the quality of the cloth.

Foreign hops were so artfully packed, that the loss to the brewers was reckoned at £20,000 a year, and an act was passed to " prevent the falsehoods practised by strangers in the packing of hops."

Among English productions, that of leather has always been one of great importance, and it has also been more cramped by fiscal regulations than any other branch of manufacture. In these times, parliament seemed to know the art of tanning, currying, and shoemaking, better than those who had to supply the market. The act of 1604, amending a former act, describes every part of the art with great minuteness, and great indeed must have been the ingenuity of tanners in those days who could have evaded any of the prescribed legal manipulations.

The penalties commenced with the butcher. If in slaughtering a steer or a cow he cut or in any way injured the hide, he was mulcted in a fine of twenty pence (about five shillings in present money); if he put water on any hide, except in the months of June, July, or August, or exposed a musty skin for sale, or killed a calf under five weeks old, he was liable to a heavy forfeit. No hide was suffered to lie in the limes till they became overlimed, nor were any skins permitted to be put into the tan-vats before the lime was perfectly sokened and washed out of them; nor was any other matter or thing to be used "about the workmanship and tanning of leather but ash bark, oak bark, tap wort, malt, meal, lime, culver-dung, or hen-dung." The skins were not to hang or lie in a wet state, nor suffered to be frozen, nor were they to be dried or parched by the heat of the summer sun, or by a fire; nor were any to be tanned that had lain either too long out of the limes, or too long in them.

Hides for "utter sole leather were to lie in the woozes at least twelve months," and hides for upper leather to lie at least nine months, and during all that time the woozes were to be kept of the necessary strength "and made strong" as often as necessary. Some tanners, says the act, "for greediness of gain use crafty and subtle practices, sometimes laying their leather in their fats set in their old tan-hills, where it may be tanned in the hot woozes, taking unkind heat in the said hill, and sometimes by putting hot woozes into their tan-fats they make leather seem both fair and well, and sufficiently tanned within a very short space;" but in future the use of hot woozes will be against the law.

Some tanners, to the "damage of the commonwealth convert insufficient hides to sole-leather, raising them by divers mixtures, and making the same feel very strong and substantial leather, whereas in wearing they prove hollow, deceitful, and altogether unprofitable for the commonwealth;" but in future no person was to raise with any mixture leather to be employed to backs, bend leather, clouting leather, or any other sole leather, except of hides sufficient in state and growth.

But as no leather can be so well tanned that it may not be marred in the currying, it was enacted that no hide was to be curried which was not "thoroughly dry after his wet season;" nor during that was "stale urine or other deceitful or subtle mixture to be used to corrupt the leather;" nor was any "utter sole leather to be made with any other mixture than hard tallow, nor with less than the stuff will receive; nor was any leather meet for over-leather and inner soles to be curried but with good and sufficient stuff, fresh and not salt, and thoroughly liquored till it can receive no more;" nor was the leather to be burned or scalded, or gashed or shaven too thin in any part, all under heavy fines. "Leather both well tanned and curried," says the act, "may by negligence, deceit, and evil workmanship of the cordwainer or shoemaker be used deceitfully to the wearer thereof;" and therefore the shoemaker was not "to make any boots, shoes, buskins, startops, slippers, or pantofles, or any part of them, with anything but English leather, well curried, (other than deer-skin, calf-skin, goat-skin, or sheep-skin, made or dressed like Spanish leather,) well and substantially sewed with good thread, well twisted and made, and sufficiently waxed with wax, well rosined, and the stitches well drawn with hand-leathers, without mixing or mingling over-leathers, that is, making over-leather part of neat and part of calves' leather;" nor was the shoemaker to put into any part of the articles that have been named "any leather made of sheep-skin, bull-hide, horse-hide, nor use for upper leather of any shoe, boot, startop, slipper, or pantofle, or the nether part of any boot, (the inner part of the shoe only excepted,) any part of a hide from which the sole leather is cut, called the wombes, neck, shank, flank, powle, or cheek, nor in the treswells of the double-soled shoes any other leather than the flanks of any of the hides described, all under a heavy fine;" nor could he expose for sale between the 1st of October and the 20th of April any shoes, buskins, or pantofles, meet for any person to wear exceeding the age of four years, except of dry English calf-skin leather or goat-skin, dressed like Spanish leather, under a penalty.

Triers of the leather, and sealers of every hide manufactured, were appointed and paid by fees, and bribery was severely punished. All sales of leather were registered, with names of buyer and seller. No shoemaker or saddler or any one who worked up leather could use leather that had not been registered, although tried and sealed, without forfeiting the goods made of it to the poor. Extensive powers of right to enter and search were given to the master and wardens of many companies, such as the girdlers, cordwainers, curriers, &c., to examine and try boots, shoes, mails, saddles, and all manner of wares made of wrought leather. No tanner could give leather to be dressed but to a currier who was a freeman, nor could any currier be a butcher, tanner, cordwainer, shoemaker, or other artificer using the cutting of leather.

The demands of the market, however, had long been stronger than the fear of penalties, and many of the absurd restrictions in the above act were evaded by incurring the penalties, and compounding for them under a patent, which had been granted during the queen's time, and which was still in operation; for King James, it was soon observed, evinced no desire to abridge his own power by disallowing the claims of the patentees. To prevent what were called "evasions of penal acts" becoming a source of profit to the court by grants of these qualifying letters patent to receive or compound for the fines and forfeitures, an extraordinary clause was inserted into the act, and passed into a law, without animadversion, from the court party:—"Be it enacted, that if any person or persons shall at any time hereafter procure or obtain any grant or letters patent purporting to give license or authority to any person or persons to dispense with or tolerate any offence against any clause, provision, or article in the present act, that then and immediately from and after such letters patent or grant obtained, all and every such clauses, articles, and provisions so by the said letters patent or grant authorized or licensed to be dispensed with or tolerated shall be utterly repealed, void, and of no effect, anything contained in the present act notwithstanding." This comprehensive clause not only completely nullified and destroyed the "prerogative royal," but shut the door to every improvement of the manufacture of leather, and opened besides the way to a parliamentary despotism infinitely more unscrupulous and oppressive than the king's which it was framed to supersede.

The transportation of artillery, which had been much blamed in the queen's time, being still permitted, apparently under license of a patent, a motion was made by the Commons to stay the export of great quantities of ordnance then waiting to be exported; the Commons applied to the Lords, "who desired the Commons to do it themselves, and they would give it furtherance," and a bill was thereupon introduced to limit the exportation.

There was also a strong impression throughout the country against undressed white woollen cloths being bought up and exported, to be finished abroad; and a bill was brought in to regulate the sorts of cloth that might be exported, "unbarbed, unshorn, and unrowed;" another, to avoid "deceits in dyeing and dressing cloth," which had an aim similar to that passed for the tanners. To complete the absurdity of some of these measures, a bill was read to prevent "ware for apparel being sold without ready money," in order to lessen the temptation to the poorer portion of society to incur ruinous expense in order to indulge their alleged taste for extravagant dress.

Bills to reform abuses (under a patent) in the manufacture of starch, and to dissolve a patent for the transportation of undressed sheep-skins, and for restraint of sowing woad, also under a patent; and for "the relief of poor artificers called blacksmiths and naylers, and for avoiding of deceits in their trades, and of oppression daily practised upon them,"—were deferred or "let to sleep" for a period; as was also a bill to regulate "how many coopers might be kept by brewers and vinegar men." In these times the "freemen of trades" stretched claims most ruinous to themselves over every thing.

"An act for an explanation of the common law in certain cases of letters patent" was also laid on the shelf for a period. It had been read by Lawrence Hide in the parliament of 1601, and was then got rid of by the queen's message and promise.

One of the most unpopular grants was that to Darcy to make cards, although its effect on the public must have been comparatively of small importance when compared with that of many others in operation throughout the country. It however destroyed a small branch of trade to the haberdashers, who formerly were the usual retail dealers in playing-cards, and they were talking sufferers. In these obnoxious letters patent the queen is made to say, in the preamble, " that perceiving divers subjects of able bodies which might go to plow, did employ themselves in the making of cards," and misliking perhaps the effeminate employment, she granted to Ralph Bowes, in 1588, the sole privilege of importing foreign cards, and also manufacturing and selling such articles in England. It appears he managed his monopoly with some address, for no very loud complaints were made of his agents. Two years before it expired, an extension of the grant for another term of years was made to Darcy, who, on the termination of Bowes's right, expended five thousand pounds in making the "devil's books." Allen, a haberdasher, who was most likely put in the foreground by his brethren, in spite of the patent, manufactured and sold playing cards, and Darcy brought an action against him for damages.

The opinion of the court has not been reported, but from the speech of Fuller, Allen's advocate, may be gathered what was the popular notion of a patent right, and what had been the practice of the court heretofore, when such a grant had been questioned.

It has been observed that Fuller made his speech and exhibited his legal courage, after the queen's proclamation and her promise to parliament, and at a time when there were suspicions of her health declining. And although he would have left little for the discretion of the queen in the exercise of her kingly power, and but a small reward to the inventor for his pains and invention, yet he made a bold, and as it happened, a successful stand for his client against the " prerogative royal."

"Commonwealths," said Fuller, "were not made for kings, but kings for commonwealths; and the law, the inheritance of all, binds both the queen and subject. If law were not, there would neither be king nor inheritance, and to *outrun the law is to let in confusion.* The queen by her patent cannot do wrong, and her prerogative is no warrant to injure the subject. Letters patent were void if they tended to change the law, or hurt any man's inheritance, or granted anything *contra commune jus*, or what tended to any general charge of the subject.

"By the law of God every man should live by his labour, and therefore, were an act of parliament to prohibit a man from living by the labour to which he was brought up, it would be void by the law of God; and, much more, letters patent.

"Arts and skill of manual occupations rise not from the queen, but from the labour and industry of men, and by the gifts of God to them tending to the good of the commonwealth and of the king; and it is a good part of a king, says Bracton, to reject no person, but to make every one profitable to the commonwealth.

"The queen, by her prerogative, cannot take twelve pence from a subject, even to carry on her war, without an act, or grant any one's lands or goods; neither can she grant twelve pence gotten by any trade, and why therefore grant away the trade? If partial affection by private discretion do govern public affairs, then one man's will becometh every one's misery.

"Before the grant of Darcy's patent, many persons were set to work in making cards—carvers, painters, carpenters, card makers, and card sellers, who maintained their families by the trade, and many persons were brought up as apprentices to it. Darcy will take from these men against their will their living and lawful trade, and force them to seek other trades.

"Before this, if any person by his industry had obtained excellent skill in his trade, he might have reaped the fruits of it, and that hath been thought the surest thing, to obtain skill and knowledge, because thieves could not steal it; but Darcy hath devised a means to take a man's skill from him which was never heard of before, and which, if others should do the like in other trades, it would discourage men to labour to be skilful in any useful art, and bring in barbarism and confusion.

"Darcy says this is no necessary trade, and so others may say of silk lace, women's tyers, gilt rapiers and daggers, whereby many thousand of good subjects may be cut off by letters patent at an instant by bare suggestion, which ought only to be done by parliament; where among the assembly of such wise men, some will consider the inconvenience, some the damage, some the profit, some the mischief, some what is meet for this place and for that; therefore it is well said of Plato, except wise men be made governors, or governors wise men, mankind shall never have quiet rest, nor virtue be able to defend itself.

"Darcy hath a power to bring all cards from beyond seas, as well as to restrain all from making and selling them. He sells his cards at thirty-five shillings a gross, the haberdashers sell better at twenty shillings; and this is *malum in se* against the common law, that cannot be dispensed with by patent, as *malum prohibitum* may be. Before the grant, if any naughty and false cards were made, one might buy of others better cards; then there were many makers and many sellers; by Darcy's patent, be they good, cheap, be they dear, you must buy all of him or of his agents in what manner it pleased him."

It had been urged that the queen could and had restrained all card-playing, and that therefore, for the particular good of the commonwealth, the card-seller may receive a particular loss in his trade—"but," continued Fuller, "it is *not* to be confessed that the queen may by letters patent without parliament restrain all card-playing. The exercise of the right, or the length of time it had remained unquestioned and been acquiesced in, did not make it valid; seisin by wrong on an unlawful patent was of no force. Time out of mind, at Canterbury, a town chandler was nominated, to whom all the butchers should sell their tallow, at a price to be settled by the mayor; but this patent was abolished by the judges when it was brought before them."

In the course of his argument Fuller assumed extraordinary powers for the judges. "All patents concerning the king and his subjects are to receive exposition and allowance how far they *are* lawful and how far *not* by the judges, and that the judges in the exposition of the letters patent are to be guided, not by the precise words of the grant, but by the laws of the realm and laws of God, and according to the ancient allowance thereof." With the exertion of a small share of ingenuity, the judge could thus make himself the law-maker as well as its expounder, and set aside the authority of both queen and parliament.

Fuller concluded by giving a description of the monopoly that he considered the crown might grant according to the law of the land. "I will show you how the judges have heretofore allowed of monopoly patents, which is, that where any man by his own charge and industry, and by his own cost and invention, doth bring any *new trade* into the realm, or any *engine tending to the furtherance of a trade*, that *never was used before*, and that for the *good* of the realm, that in that case the king may grant unto him a monopoly patent for some reasonable time, until the *subject may learn the same*, in consideration of the good that he doth bring by his invention to the commonwealth, otherwise not."

This contracted view of the patent right does not essentially differ from that which jurists admit now, and its grinding, grasping spirit descending to our times, continues to inflict infinite hardship and oppression on inventors of every description.

1605. There appears to have been a considerable trade in exporting undressed coney skins. The "merchants" bought them by retail, but by the act they were prohibited from buying less than 1000 black coney skins, or 3000 grey skins, or 2000 lamb skins or morkins at one time, and these were all to be perfectly wrought, dressed, and packed by "artisan skinners" within the kingdom. The furrier's trade was better understood in Flanders than here.

"Beer may be transported with its cask," when the quarter of malt was about sixteen shillings.

Coaches were now in common use.

"Rapiers, swords, and daggers," says Stubbs, "were gilt twice or thrice over the hilts with angel gold, others damasked, varnished, engraven, marvelously goodly; and least any thing be wanting to set forth their pride, the scabbards and sheaths are of velvet or the like, for leather, though it be more profitable and so seemly, yet will not carry such majority or glorious show as the other."

Hatching the hilt is supposed to have been done by furrowing it with a file and then silvering or gilding the hatchings.

1606. Leather was not in future to be sold by weight, because in despite of the laws it was neither "sufficiently tanned nor thoroughly dried as it ought to be, and as in before time it was wont to be."

By the new regulation of the woollen trade there was to be "no rowing or raising of cloth or kersies with any oils, goose grease, swine's grease, or any other liquid or moist thing, but only on the edge of the shears with semit or oil; nor was any wool to be cut from the back of the cloth by any knife, rubber, or pumice-stone or other device whatever, but only by shears," under a penalty of a mark. No cloth worker was "to spout or bedew any kind of broadcloth with any liquid or moist thing, whereby the edge would show to be better than in the ridge or crest, to deceive the searchers and buyers, and show greater weight!"

Flocks, thrumbs, crums, and lambswool might now be made into cloth under certain regulations, one of which was to have one list wholly of black yarn, and the other side a selvage only.

The exportation of coloured woollen cloths was restrained.

At the commencement, in April, of a debate on "grievances produced by the grants of letters patent," the Speaker moved that as the list of them which had been drawn up in the last session was read, that they should be classed by the vote of the House into such as were warranted by law, yet grievous, and such as were against the law. The patents for the transportation of ordnance, for licensing sale of wines, for the pre-emption of tin, for the use of logwood, for new draperies, for wools, for blue starch, for saltpetre, for green wax, for issues, for imposition of serges at Southampton, and some others, were discussed separately during three weeks, and voted into the classes recommended by the Speaker; after a hearing, in many cases, of the patentees in person and their counsel—three or four only were exempted from the charge of being grievances.

A preamble of grievances, and a list of them which had been examined, was engrossed, and in May Sir Francis Bacon, with a deputation, presented it to the king, who in reply asked "if the grievances were not begun in the queen's time, and yet she was a just and glorious sovereign. An O-yes was made for the grievances, but the list presented to him should be read, and read again, and every article put to its proper forge; matters of law to judges, other matters to men knowing in their profession. I carry an even mind, said the king, and I will hear the meanest subject in his grievance."

At the opening of the next session of parliament, his majesty said that "the propositions made in the last session were of two sorts, concerning matters of government proceeding from the king, and matters of grievance of the commonwealth proceeding from the subjects; but that himself would not be accounted one of those kings who would prefer any propositions of his own before the people's just complaints, nor one who would not reform an ancient grievance before he would carry out his own measure. For the grievances themselves, he said, they had been collected with more industry than lawful or dutiful diligence, yet they were penned and presented in a form so full of discretion and moderation that he was loth his answer should smell of the spirit of Rehoboam.

"But the matters of grievance were such as if they were unlawful they ought to be removed; if they were lawful, and yet unlawfully abused in execution, the abuse was to be reformed; or if they were doubtful in law, they were fit to be referred to trial and judgment, which order and distinction he had observed in his answers and resolutions to every one of the grievances; and he observed that it was not becoming for a parliament to present any but apparent and just causes of grievance, for in his own nature and mind he was ever prepared to relieve any just complaint of any private man that might appear before him.

"But there is in parliament, as there is in all multitudes, diversities of spirit, as there was among the very apostles themselves, and that some of them were more popular than profitable either for that council or for the commonwealth, and that there were some tribunes of the people whose mouths could not be stopped; but for himself, he would never make a separation of the people's will from the will of the king. He would offer one admonition unto the lower house of parliament, that they ought to enter into a double consideration of themselves,—one, as they were subjects in general, another, as they were specially called to be counsellors of the kingdom, and that the thought of one ought not to make them forget the consideration of the other. He wished that the members would know and observe him, and that if any such plebeian tribunes should incur any offence, or commit any such error, they would correct them for it and judge themselves, as St. Paul saith, that they be not judged, and that the whole body receive not a wound by one ill member thereof."

Next day, the clerk of the House of Lords, by the king's command, delivered to the Speaker a parchment roll, which was a memorial of the king in council, on the list of grievances which had been presented to him by Sir Francis Bacon.

The patent granted on account of certain services in Ireland to Sir John Gilbert and Lord Danvers of certain forfeitures, was revoked, and pensions were given to the patentees.

The patents for green wax, and that to Sir Henry Bronker, were surrendered by Sir Roger Aston and Sir Henry, and new patents granted, with the desired limitations.

The patent to the Lord Admiral to sell wines "was good in law, though the patentees have abused the House with many untruths."

The patent to use a mixture of logwood and other things in dyeing is found to be good and profitable for dyeing; both sides were heard by the council, and the grant found good in law, and some abuses alleged by the opponents of the patent were proved false upon the hearing. Nevertheless, says the memorial, "such is and ever shall be his majesty's care to prevent all cause of vexation to his subjects, particularly where tending to discredit the making of cloth, which is one of the greatest and richest manufactures in the kingdom, that he hath been pleased to resume this grant by the consent of the patentees, notwithstanding the yearly rent of £500 reserved to himself, and further profit of good value to others interested in it; and his majesty is pleased to take some other course, though to his own charge, for their recompense, rather than his subjects shall have just cause of complaint."

The patent for the imposition on corants has been submitted to the courts of law, and publicly pleaded for and against the king, with a final judgment in his favour.

The patent for tobacco is left to the same course.

The patent to the Duke of Lennox for new draperies is left to be judged of by the law, and any abuse in execution that appears shall be punished.

The patent for the pre-emption of tin is a grant of a right of inheritance anciently and justly pertaining to his majesty. "The exception to this," says the memorial, "does not appear to be worthy the name of a grievance, unless abuses are committed in its execution, which shall be reformed on complaint; under it a great number of his majesty's subjects in Cornwall that live by their labour receive great relief and reasonable payments for work, for which formerly they were paid what the merchants list."

The patent for making smalt or blue starch, granted on suggestion of its being a means of setting a number of poor persons at work, is left to the decision of the law.

Patent for transportation of iron ordnance and bullets, is good in law; but no grants have lately passed of such a nature, and his majesty will be sparing of them in future.

The patent for getting saltpetre was granted by his majesty, but is more limited than the one granted in the queen's time. "It was not meant to be an application of his prerogative further than to show himself not so improvident as to suffer his crown and people to depend upon the uncertainty of foreign supply of this article.

"Divers injuries, however, and grievances have been offered by some of the meanest persons employed therein, which are injurious to the authority of the grant, rightly examined, and to his majesty's meaning. For these among other reasons his majesty has revoked all grants made to work saltpetre, intending to consider of some course hereafter by which it can be made without any fresh cause of complaint to his subjects."

The candour and fairness which characterizes this memorial in its admissions and decisions, and the moderation with which rights are claimed, contrast most favourably with the crooked promises of his predecessor, and with the grasping, suspicious spirit of the parliament, which while forcing the king on a review of his measures, had without scruple assumed on several occasions an unconstitutional power to themselves.

1606. It is not known that Lord Mountjoy made any attempt to manufacture alum under the patent assigned to him by De Vos in 1587. But De Vos himself is said to have made copperas. That Lord Mountjoy did not engage in the project is most probable, as no mention is made of the patent to De Vos and him, in a patent which was granted this year to "LORD SHEFFIELD, SIR THOMAS CHALLENOR, SIR DAVID FOWLYS, and JOHN BOURCHIER, ESQ., of divers absolute, full, free licenses, touching the sole and only making of allomes and liquors thereof in England, Scotland, and Ireland, for 31 years, in consideration of a yearly payment to the king of £700."

Lord Sheffield and his partners assigned a moiety of their interest to five London merchants, Turner, Cryspe, Hynde, Cryspe, and Chambrelane, with power "to dig, open, and worke for all manner of mines and ewers of allomes within the lands of Lord Sheffield and his partners in Yorkshire or elsewhere in the three kingdoms." The adventurers were to erect all necessary buildings, find plant of every description, disburse all expenses of working and manufacturing the allomes and liquors at their own risk, and without claim on Lord Sheffield or his partners; and for their outlay and risk Turner and his partners were to have one half of the clear profit arising from the sale of the alum.

The anticipation of immense gain from this grant encouraged the adventurers to embark large sums in buildings. A question was then raised by the crown, whether the patent granted to Lord Sheffield was a legal one. "Allome digged was held to be a *metal*," (although allomes from liquor was not,) over which the king had the same right under his prerogative royal, as over mines of gold and tin, which the law held were never conveyed by a grant of the land in which they might be found. The patentees and adventurers found it prudent to acquiesce in this claim, and surrender their patent to the king, on condition that the adventurers were to be repaid the money expended under the patent in buildings and stock, and the original patentees secured in annuities from the king, who took the whole concern into his own hands. Cecil, the lord treasurer, and Cæsar, the lord chancellor, were the king's agents. The adventurers, who appear to have acted in person, managed to get good terms for themselves. They were to be paid £6,044 a year, in full of money expended and prospective profit; and Lord Sheffield and his three partners were to receive £4,000 a year, to be increased to £6,000 a year at the third year.

The king then granted to the adventurers a long lease of all the buildings and plant which he had bought of them, and a half of all the profits that would accrue from the sale of the alum, for a certain payment in ready money, and a payment for the first year of £5,000, increased to £11,000 at the third year, and continuing at this rent for a certain number of years.

By this arrangement, instead of £700 a year, which the king reserved to himself under the first patent, he now had the half of the whole profit, and the reversion of the buildings and plant. It was stated that his half share brought him in £18,000 a year; and large gains were made by the patentees, who carried on the whole concern, and made all the disbursements for manufacturing and materials from their own means and at their own risk. The king bound them, however, to build and maintain as many alum houses in the three kingdoms as would make 2,000 tons of alum annually, and never to have less than 100 tons on hand, which he bound them to sell to the public at £26 a ton, that being the market price of foreign alum at that period.

To encourage his own trade, the king issued a proclamation prohibiting for thirty-one years the importation of foreign alum, under heavy penalties. The adventurers, however, stipulated that they might import it, free of all duties, and also export their own alum with exemption from impost. They also reserved to themselves the power of "suing their debtors in his majesty's name, with as large a privilege as his majesty may do in his own case," and even "use his name for their own private uses, and assign bonds taken in their own name to the king." They had authority at all times, by day and by night, in any place, to go on board of all ships and to seize and confiscate foreign alum. And if the king licensed the importation of alum into Scotland, they were to have a claim for the defalcation of their profits, and to keep the amount in their own hands, as a deduction from their rent.

It is said the discovery of the aluminous earth was made by Sir Thomas Challenor. In his travels the knight had visited Italy and resided some time at Rome; he thus became acquainted with the appearance and properties of aluminous earth, and had acquired some knowledge of the chemical process of separating the alum. "At his return to England he practised chemistry with a rational freedom uncommon in that whimsical reign. Knowing the value attached to the privilege, he was induced to add his knowledge to the influence of his three partners to carry the business through the court, where every one was opposed to his neighbour's monopoly, but straining and gaping to have one of his own." It is also related that with all Sir Thomas's skill and knowledge "all things could not fadge with the patentees until they had brought, not to say stolen, over three prime workmen in hogsheads from Rochelle, in France, whereof one was Lambert Russel by name, and a Walloon by birth."

When the work was thus far completed, the establishment at Gisborough was adjudged a mine royal, and passed into the power of the crown. "The works were afterwards rented by Sir Paul Pindar, under a limitation as to the quantity to be manufactured, who paid £12,500 a year to the king, £1,640 a year to Lord Mulgrave, and £600 a year to Sir W. Penniman, besides large salaries to numerous clerks, wages to rubbish-men, rock-men, pit-men, house-men, fire-men, so that at one time, when the mines were in their majesty, he had in his employment no fewer than 800 persons by sea and land. Yet did not the knight complain of his bargain, who having the sole sale of the commodity to himself kept up the reputation thereof, and the price at £26 a ton; and this he did the easier because no better and scarce other was in all Europe, save what came from Rome and Rochelle."

1607. A great change had taken place in the art of war. Fire-arms had now nearly superseded the ancient catapultæ and bows, but nevertheless a strong prejudice remained among military veterans in favour of the discarded weapons, and which is in a great measure to be referred to the imperfect construction of the modern missiles, in which accuracy of workmanship was essential to their effective action.

"Without all question," says a military writer who lived near this time, "the guns which are used now-a-days are neither so terrible in battle, nor do such execution, nor work such confusion as arrows can do; for bullets being not seen only hurt where they hit, but arrows enrage the horse and breake the array, and terrify all that behold them in the bodies of their neighbours, not to say that every archer can shoot thrice to a gunner's once, and that whole squadrons of bows may let fly at one time, when only one or two files of musqueteers can discharge at once."

Bingham says, "Our own stories testify that the great battles we gained against the French were gained by the means of our archers principally; and that the English have heretofore excelled in archery and shootinge is clear by testimony even of strangers, Cicuta commending the use of bows as necessary for the service of the field, and that long after guns were invented preferreth the English before all other, and setteth them down as a pattern to follow; and Patritius disputing of the violence of arrows, doubteth not to affirm that an English arrow with a little wax put upon the point of the head wil passe through any ordinary corslette or cuiras. It may not be denied that the force of fire weapons of our time doth farre exceed the height of all old inventions, and when I have given them the first place I will not doubt to give the second to bows and arrows. Nowe then for us to leave the bowe, being a weapon of so great efficacie, so ready, so familiar, so domesticall as it were to our nation, to which we were wont to be accustomed to from our cradle, because other nations take themselves to the musket, hath not so much as any shame of reason. Other nations may well forbear that they never had. Neither Italian, nor Spaniard, nor French, nor Dutch, have these 500 years been accounted archers; it was a skill almost appropriated to our nation; by it we gained the battles of Cressy and Poictiers, of Agincourt in France, of Navarre in Spain; by it we made ourselves famous all over Christendom; and to give over upon a conceite only, for no conceite can ever show that our bow was ever beaten out of the field by a musket, will prove an imitation of Æsop's dogge, who carrying a piece of fleshe in his mouthe over a river, snatched at the shadowe and left the fleshe. I speake not this to abuse the service of muskets."

Horse armour had been laid aside in Germany, and was wearing out in England. About this time, however, body armour was made very heavy and massy—"it was so exceedingly strong as to seem to load the wearer with anvils—a young gentleman 30 years of age is quite maimed in his shoulders with such a burden." King James, with his usual sagacity, said he "could not but greatly praise armour, as it not only protected the wearer, but also prevented him from injuring any other person."

The use of sword and buckler also ended about this time. While they were employed, all haberdashers sold bucklers.

A petition of the armourers and gun makers to Parliament states, that

Henry VIII. invited many German armourers to work and settle in England, and made some liberal grants to them. These artists instructed great numbers of native workmen, so that in Queen Elizabeth's time there were thirty-five armourers who kept shops and servants in the city. At this date, however, five only of these artizans were remaining, none of whom kept more than one servant, and were besides scant of employment. This decay of trade was attributed to the king's having repealed, at his accession, an act passed by Philip and Mary, by which magistrates were authorized to enjoin all householders to have a provision of armour in their possession. The Parliament directed that a motion might be made to the Privy Council to issue their letters to the lords-lieutenant and justices, expressing their pleasure and desire that under these circumstances all men might be at liberty to buy armour and weapons of other armourers, as well as of one Edmund Nicholson, who had been appointed by their lordships' warrant to serve the country with armour and weapons; a recommendation from which it might be inferred the Privy Council itself was not considered by parliament to have been inaccessible to the usual "inducements" for granting a monopoly.

A common prejudice in this as well as in the latter part of the preceding reign was attempted to be embodied in a law to "avoid the wasting of wheat by making it into starch;" the measure, however, was deferred for a period. There was a monopoly of starch, and that as far as it went must have acted as a prohibition.

The use of logwood in dyeing was still resolutely opposed; a remonstrance of some clothiers says, "Notwithstanding all former laws against keeping and using this obnoxious dyewood, it was continually imported and used, to the hindrance of the king and his custom of £10,000 a year, and to the wrong of his subjects, who buy deceitful dyes for sure colours, to the great *aspersion of our religion*, and scandal of our nation, hindrance of merchandize and shipping, and employment of the poor." A bill was read twice to make the importation *felony*, but it was judged expedient to "let it sleep" for a period.

1608. Rapin says, that one of the means devised to get the king money was to form a monopoly for the sale of cloths. The company of merchant adventurers had a patent for the exportation of white undyed woollen cloths; but this privilege was and had long been very unpopular, and more particularly now in consequence of great numbers of cloth makers in all branches being without employment, and the trade in a state of great depression. It was urged that much of the white cloth sent beyond sea was returned dressed and dyed, for the English were in this art much inferior in skill to the Flemings. The encouragement of the staple and of the native workmen was therefore put forth as a sort of popular wish, which was diligently fostered by some influential persons with an intention to turn it to their own private advantage.

Alderman Cockaigne says, Coke, taking advantage of the general feeling, intimated to the ministry that a great profit would accrue to the country, besides opening a source of employment to the idle clothiers, if no woollen cloths were allowed to be sent out of the country undyed and undressed. He offered large sums of money to Rochester, Southampton, and the lord treasurer, and to the exclusion of all others, procured a patent for dressing and dyeing all woollen cloths that should be sold in the country and sent abroad. He then got the king to withdraw his license to export white cloths from the merchant adventurers, and to publish a proclamation prohibiting undressed white cloths being sent abroad, or to import foreign dyed and dressed woollen fabrics. No series of measures could more effectually confine the whole trade to the native workmen.

On the other hand the Hollanders, to protect their interest, prohibited importation of English dyed cloth into their ports. The effect on the home market of this unnatural state of things was soon apparent. The alderman and his company were not able to dye all the cloths that were fabricated, and what they did dress and finish were dearer and worse in quality than the Dutch cloths; and the gross sales for home use were a comparatively small quantity, when compared to the whole manufactured produce. Large quantities both of rough and dyed goods lay, therefore, on the hands of the clothiers, and infinite numbers, says Coke, of poor people were thus laid idle, and reduced to a starving condition, which at last raised such a clamour, that the king was obliged to permit a certain quantity of white cloths to be exported, to ease the market.

Walter Busbee, who was assay master to Goldsmith's Hall, was sent to the Grand Duke of Russia, for the purpose of making for him a standard of gold and silver in his mint, the same as that in the Tower of London, "which shows the high estimation that standard was held in abroad, which was introduced by King James."

1609. To protect the comb, spoon, and cup makers, whose trades were falling rapidly into decay, no person was to sell English horns unwrought to a stranger, or export them, under a heavy penalty. Flemish and French articles were driving those of England from their own markets.

1610. An alleged improvement had been made on Spanish cloth, and the improver requested "that it might be looked on by some clothiers of the House, and encouragement given, as it made the cloth more vendible;" wherein it consisted was not stated.

In a proclamation the king says, that "all grants and monopolies of the benefit of penal laws, or of power to dispense with the law, or to compound for the forfeiture, are contrary to the law, and that no suitor should in future presume to solicit him for such grants." The admissions in this proclamation were *held* by the ruling party in parliament to be founded on a true interpretation of the ancient law, and were constantly referred to afterwards in the discussions between the king and parliament. Thirteen years after this period they were triumphantly embalmed as relics, the preamble to the act which defined and limited an obnoxious branch of the prerogative royal.

1611. Patent to JOHN SPEEDE to print for ten years his "Genealogies of the Holy Scriptures," and also a "Mappe of the Land of Canaan, which we (the king) adjudge worthy to be inserted in convenient manner and due place into every edition of the Bible newly translated."

About this period some alteration was made in the model of ships of war, of which Sir Walter Raleigh is said to have been the author.

Machine for cutting tobacco introduced.

1611, 1612. Mr. William Burrel proposed to build ships of war in Ireland, at one half of the cost of building them in England. He offered to build ships from 100 to 600 tons burden, with two decks and a half, according to the usual model and scantling of the king's ships, for £5 a ton. To paint, carve, and finish the joiner's work for 10*s*. additional, and this would include the labour for rigging, the king finding the material. The moulds were to be agreed on by the king's surveyors, and the work to be executed under the superintendence of the same persons, and to be gauged in the common manner. Ship and cargo were to be brought to London at Burrel's charge, and Baker, Bright, and Pett, the surveyors, recommended the offer to be accepted, as £6 a ton would be saved to the king; and Pett was appointed to proceed to Ireland to superintend Burrel's operations under the contract.

1612. Patent to SIMON STURTEVANT for "divers mechanic arts and mysteries of his own invention, whereby all kinds of metal workes and materials, as iron, steele, lead, tins, coppers, brasses, and such like, and all kinds of metalique concoctions, as sand, mettles, ash mettles, ammells, and such like; and all kinds of burnt earths, as tiles, paving-stones, bricks, and such like; and all kinds of press wares, as prest tiles, prest bricks, prest monions, prest stones, and diverse other things now made after the ordinarie course with wood fuel and charcoal, may bee as well made and wroughte with sea cole, pit coale, earth cole, and brush fewel, whereof the woodes now generally wasted in all the chiefe woodland countries of the realme, by iron milnes and such other metallical furnaces and hearths, may be preserved; and also for the better making and heating of these matters he hath invented furnaces, hearths, tests, tools, engines, milnes, not heretofore used in these arts and mysteries."

The privilege was granted for 31 years. The profits were to be divided into 33 parts, 10 of which were to go to the king, five to Prince Henry, two to the Duke of York, and one to Viscount Rochester; the remaining 15 shares were to be the property of the patentee, who was to find all the money and run the whole risk.

On many accounts this was one of the most important and promising projects of the period. All iron articles and pottery ware were high priced, and in some districts iron smelting was forbidden, from the waste it made of the wood, which was rapidly diminishing. Sturtevant's estimate of the saving that would be made by the adoption of his methods was far from being overstated. "To speake nothing," says he, "of the great benefit and profit which may be raised and made by twentie other inventions comprised and comprehended under the pattent, the yearly vallew of this mettle businesse alone will amount unto £330,000 per annum, as appeareth by this calculation.

"There are planted already in England and Wales 800 milnes for the making of iron; for there are 400 milnes in Surrey, Kent, and Sussex, as the townsmen of Haslemore have testified and numbered unto me; there are also 200 milnes in Wales, and 20 in Nottinghamshire. Now we may well suppose that all England, Scotland, and Ireland will make up the number of 180 milnes more, being in all 800 milnes.

"Moreover, one milne alone spendeth yearly in charcoale £500 and more, as diverse clarks and workmen in iron businesse have credibly testified, which in pit coale will be done with the charges of £30 or £40 after the inventioner's manner, or at the most £50, where the carriage is farre and chargeable. So that this new invention in the 800 iron milnes will save and gaine, *de claro* the owners of those milnes, £320,000 yearly, over and above their ordinarie and annual gaines; for one milne saveth yearly £400, ergo 800 milnes save yearly £320,000, by conforming their furnaces, fineries, chafferies, to this invention of pit coale.

"Brick making, brewing, dyeing, casting of brasse works, were not many years since done altogether with wood fuel and charcoal, instead whereof coale is now used as effectually. The blacksmithe also long agone forged all his iron with charcoale, as in some places where they continue this course still, but these many yeares small sea coale doth serve the turne as well; add hereunto, that verie lately by a winde furnace greene glasse for windows is made as well with pit coale, at Winchester House, in Southwarke, as it is done in other places with much wast and consuming of infinite stores of billets and other wood fuel."

Sturtevant prepared his coal by charring, to get rid of hurtful matters; his invention of "prest bricks, minions, &c.," has been recently revived, and is one that bids fair to be of great importance to the public.

His patent also contained a privilege for making "new kindes of *water milnes*, winde milnes, winde water milnes, for the grinding of corne, tanners bark, brazill; for the sawing of woods, making of oyls, battering of irons and coppers, and for tuckage and fullage of wollen clothe, or yellow oyled leathers. These metal-organicke milnes are lesse chargeable to set up, keepe, and repaire, than the ordinarie sort of milnes in use. Excellent devices and meanes for the *dreyning* and drying of *marshes*, fenns, and low grounde, and for mounting, ridding, and clearing water out of coale pits. For the *fertilizing*, improving, and hartening of *pasture ground; nettage* and bateage, by which new devised means great abundance of fish may be caught. By means of certain instruments to make *wood pleits*, or divers kinds of household moveables, as artificial doors, windowes, curtains, presses, tables, stooles, bedsteads, hangings, chests, and divers other thinges handsomer and more convenient than, heretofore, is done by ordinarie way of other stuffe."

Sturtevant, aware of the reception that awaited some of his projects, puts the anticipated objections in the form of a dialogue.

"Why, then, it seemeth that all arts, sciences, trades, crafts, things and devices which are now extant in the commonwealth, are and may be called inventions?

"Yea, verily, so they may, if we respect the inventioner and first authors of them, but if we respect the persons that use and put them in practice, as artificers, tradesmen, and others, they are called arts, trades, crafts, sciences, mysteries, occupations, professions, slights.

"To what serveth the knowledge of this?

"This fitly serveth to refute the erroneous folly of such shallow simple persons, which cannot abide any new invention which this our age bringeth forth, they utterly detest both the projects and the inventioners. They forsoothe, as they say, will give no assistance; they will not meddle nor deale with them; they will not use their goode worke, though never so goode and profitable; nay, they say more after their fonde fashion, it will never prove goode, or come to passe, with a hundred suche like speeches, tending to the dispraise both of the inventioner and of things devised by him; but being demanded for their reason, they have none to allege, except only a woman's reason, 'I do not like you.' If you ask why, 'I cannot say—only I do not like you;' but if these men who soe much spurne at inventions did well consider that all auncient mechanick trades, occupations, and workes which are now in use in the commonwealth were new at the first, and how they were then the peculiar inventions of some ingenious wits who travailled with all their endeavours to bring forthe the said inventions to the goode of that age wherein they lived, they would not be so averse and bitter against laudable and good projects brought forthe now-a-dayes. With as good reason they might enveigh against the ordinarie wayes of making salts, alloms, coppresses, saultpeter, hats, knit stockings, shoes, saddles, casts, ploughs, and harrows. In scorning and contemning businesse of late invention they set themselves not only against man but also against the Spirit of God, who is the author of the said giftes, and first worke of them in man, as it is expressly taught, in the example of two worthy inventioners and artificers; 'Behold,' saith God to Moses, 'I have called by name Bezaleel, the sonne of Uri, the sonne of Hur, of the tribe of Judah, whom I have filled with the Spirit of God in wisdome, and in understanding, and in knowledge, and in all workmanship, to find out curious workes, to worke in gold, in silver, and in brasse, and also the art to set stones, and carve in timber, and to worke in all manner of workmanship; and behold, I have joined with him Aholiab, the sonne of Ahisamah, of the tribe of Dan; and in the heartes of all that are wise hearted I have put wisdome to make all that I have commanded thee;' out of which words of Holy Scripture it is apparent that all mechanical arts and inventions, as well as the graces of salvation, are the peculiar workes and gifts of God's Holy Spirit in man, which bloweth where and when it listeth, and poureth out his Spirit on some men in every age."

Patent to FOWLE, DYKES, and DORRINGTON, for the sole making of gold and silver thread. The privilege was granted to the Countess of Bedford, who nominated the parties in the patent. This lady is described as having been a great heiress, a patroness of the wits of the age, and a collector of ancient medals.—"Who foole like waisted her owne meanes, and the estate of her husbande." This patent was opposed, and surrendered in 1616. Another grant was made to Fowle and Dykes.

1613. It has been noticed under the date 1558, that Jacob Venaline, as Fuller writes his name, an Italian, made glass in London. In 1567 Anthony Been and John Care had a privilege for 21 years to build furnaces and make window glass, similar to that manufactured in France. Their glass-house is said to have been at Greenwich. In 1576 Care's assignees had the license enlarged for 21 years, and the importation of foreign glass was prohibited, and as an equivalent a heavy custom was levied on the patent glass. The grant to Sir Jerome Bowes, already noticed, is dated 1588, for 12 years, to commence from the expiration of the grant to Care's assigns. At this period there were 14 glass-houses in England, probably under several distinct grants. It has been said that the glass manufactured at Greenwich was equal to foreign glass—the fact is doubtful. One hundred years after this period, crystal, or crystal glass, continued to be greatly inferior to the foreign article, and its inferior quality as well as higher price was the constant subject of complaint.

The patent to Sir Jerome Bowes excited much hostility, and it appears to have been cancelled or called in by the king.

A patent was issued for the manufacture of *crystal glass with seacoale* to SIR ROBERT MANSEL and others. This patent, although standing on very different ground from that to Bowes, had also the misfortune to be unpopular from its commencement. Nevertheless, if the application of sea coal had not been made by the patentees, the home glass trade must have been abandoned. A prohibition of foreign glass was made in Sir Robert's favour, and he and his friends sunk large sums of money in the undertaking.

This grant was brought before the Committee of Grievances, who reported that it was a "pregnant monopoly," and a "surreptitious patent." Fuller, a lawyer, who, as we have seen, distinguished himself as counsel against Darcy's patent, when it was demolished, said, "Now to glass, after to iron, and after to all other trades. This was like taking away the millstone from the poor." It was ordered without one negative voice that the patentees should bring the patent to the House. Other licenses for making glass seem to have been in existence, for the merchants stated, that "if *all* these patents for making glass might be called in, that glass should be sold here by importation for three pence, which now costeth sixteen pence." The king was freed from blame. "In my place of cutter of his meat I attended the king," said Sir William Chute, "last night at supper, when his majesty said, that for the patent for glass he looked for thanks for it from the house, for he had taken great pains in it. He had given order for the drawing of it to my lord Cooke, and that he had refused a thousand pounds for it, and that although a grave member of the house and the counsel for the patentees had been hemmed down when they would speak, he excused the proceedings of the house."

Sir Robert's patent was afterwards produced by a member, but with a protestation that the patentees did it only in obedience to the order of the House, and to be left there as belonging in right to the patentees.

The abuse of letters patent was carried to a greater length now than even under the queen. "Two petitions," said Sir Edward Sands, "were presented last parliament to the king; one against currants was answered, the other against *eleven hundred* impositions was never answered by writing, but only by word, by my lord treasurer.

Some other princes had imposed on four or five things, but never claimed any right, and but for a few months, and which at the prayer of the Commons were put down. Now the king had imposed on as many hundred, and claimed the right in open parliament, and made the grants *perpetual* by letters patent. This liberty trenches on the foundation of all our interests—maketh us bondmen, giveth use but no property, and by the same reason laws may be made without parliament." Mr. Whitlocke suggested that they should satisfy the king this prerogative was "no flower of the crown, and that none could show an instance of its exercise before Edward I., which he abated on complaint, tyeing himself to forbear in future without parliament. Edward III. took off, 'as wrongs,' some impositions, and from his to Queen Mary's time there were none attempted, so if it were a flower, it had a long winter, not budding in 160 years." But, said another member, "the king is a million and upwards in debt." To this it was replied, "if all the toll exacted went to the estate of the king it would more than defray his expenses."

Money so scarce that there was not sufficient in circulation to enable borrowers to tender the principal. Sir Robert Cotton advised an attempt to lessen the imports and increase the exports, but his advice was not followed, and the ruinous expedient of lowering the standard was resorted to.

The want of coins of small value had driven private traders to supply the deficiency of the legal coinage, and they had for some years struck *farthing tokens* in lead, which "passed between vintners, tapsters, chandlers, bakers, and other like tradesmen, and their customers, to pay for such small portions and quantities of things vendible, as the necessity and use of the poorer sort of people oftentimes required. His majesty being willing to continue to his subjects the good arising from the use of such small monies, had granted letters patent to LORD HARRINGTON to make such a competent quantity of *farthing tokens of copper* as might be conveniently issued among his subjects." This patent was for three years. Lord Harrington was to pay into the receipt all profit above £20,000. The king being informed, while the patent was under the privy seal, that the grant was worth £60,000, allowed him £25,000, as it should be raised by issuing the tokens, and the surplus to come to the king. From the name of the patentee the tokens were called "Harringtons."

They were circulated at first with great difficulty, and in the counties of Derby, Stafford, Flint, and Denbigh, they refused to take them. In all those counties where they were current they had hardly, in six months, uttered £600 worth. The rechange at first was heavy, and it once rose to £50 a week. Gerrard Malynes was their inventor; he says, "he was accused that there was an intention to bring in the use of copper money, which tokens are found to be very commodious and necessary, whereby the waste of much silver is prevented, the meere poore releeved, and manie of their lives saved; and the commonwealth cannot be without them unless leaden tokens were made againe."

The patent turned out to be a very lucrative one in the hands of Lord Harrington's widow and son. It was found, however, very difficult to check the circulation of the old leaden tokens, as their manufacture was most profitable to the tradesmen.

Artillery still comprehends, in inventories, long-bows, cross-bows, slur-bows and stone-bows, scorpions, rams, catapults, formerly used, cannon, baselisks, culverins, jakers, faulcons, minions, fowlers, chambers, harquebusses, calivers, petronels, pistols, dags, divided into great ordnance and shot guns.

To prevent soldiers' matches being seen in the night, small tubes of tin or copper, pierced full of holes, were invented to hold them in, by Prince Maurice, of Orange.

Great disturbances were raised in Norwich, because the Dutchmen began to exercise the "ancient trades" of the city, contrary to their agreement at coming in!

The Walloons who came over in Queen Elizabeth's time, and were workers of thread, settled at Maidstone. Hasted says the thread manufacture was carried to a great height when those industrious people had the management of it, and was now very advantageous to the town[a].

King James at his accession made peace with Spain, when a strange revolution took place in mercantile opinion and practice. The English exporters revived an absurd practice, then nearly obsolete, of hiring foreign vessels, instead of building ships for themselves. The Trinity House petitioned the king, and pointed out the danger of perseverance in this pernicious system, but the merchants prevented a bill being passed to compel exportation in English craft.

Chance produced what prudence had failed in. Two Dutch ships laden with coffee arrived in the Thames, the property of two Dutch merchants in London. The eyes of the community were opened, and the wish for an English mercantile navy spread like wildfire. A new era commences at this date. According to Sir William Monson, a ship of 100 tons built in England was a kind of prodigy at the death of Queen Elizabeth; but at the close of her successor's reign, trade ships of 300, 400, and 500 tons were built in the country.

Previous to 1613 twelve different voyages are known to have been undertaken to the East Indies by various adventurers on their distinct stocks, in ships of small tonnage. That year, or shortly after, the interests were united, and a joint-stock trading adventure was made in a small fleet, consisting of one ship of 650 tons, one of 500 tons, one of 300 tons, and a fourth of 200 tons. Shortly after a ship of 1,200 tons was built, which appears to have been the first that was launched for the East India Company. King James dined on board on that occasion, and christened her the "Trades Encrease," a name of auspicious omen. About this time not more than 10 vessels of 200 tons belonged to the port of London.

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[a] Hasted says the Walloon families are now quite worn out. The only remembrance of them left is the term *Dutch work*, which the common people give to the thread spun for the threadman. The trade was declining when he wrote, as the same manufacture was set up in the West of England, where provisions were cheaper; but even in the West of England *Maidstone thread* was preferred to any other.

About 1610 Phineas Pett built a ship of war of 1,400 tons burden, and carrying 64 cannon. It was the largest ever built in England.

The striking or jointed topmasts, "which are a wonderful ease to ships both great and small, at sea and in harbour," were introduced during the time of Sir Walter Raleigh. Four masts placed in the largest ships, instead of three, is another improvement made at the same time. No ships in the Spanish Armada, though two or three were superior in size to the English, had more than three masts.

The introduction of the chain-pump into ships dates from about the same period.

The best cables were had from "Muscovia," and were reckoned somewhat lighter than the English cable. A 17 inch cable, 96 fathoms long, weighed 50 cwt. 3 qrs. and 11 lbs.

1614. The ladies at this as they have been in most periods, were great encouragers of the manufactures. It was thought, however, that the love of finery in both sexes might be repressed with advantage to the commonwealth. When Mr. Brooke tendered a bill against extravagance in apparel, he observed, that "Women carry manors and thousands of oak trees on their necks, and it was right this evil should be repressed, for God regardeth both the substance and the fashion thereof." He proposed that the bailiffs, or knight marshall's men, should be authorized to seize the gold lace even on dresses; and he observed, that there was no fear that bloodshed would accrue by carrying this provision into effect, for most of those who were bedizen'd from head to foot would be as much afraid to encounter a bailiff with extra lace on their clothing, as they were loth to look on him without gold or silver in their pocket. A second provision created a new penalty. Such person as was convicted of wearing unseemly apparel was to be "accounted a vain idle fellow, and a fool," by act of parliament.

On this bill a modern writer has observed that there seemed to be a lack of wisdom in thus repressing the consumption of a manufacture, and at the same time complain that those whose trade it was were starving from want of employment.

A patent called that of the French Company, granted to some merchants for trading exclusively to France, was reported by the Grievance Committee as having "its preface contrary to the body of the patent, the pretence of the preface being against monopolies, the grant a plain monopoly of trade." MR. DUNCOMBE.—Free trade is every man's inheritance and birthright. This wicked patent is the undoing of many thousand families of spinsters and weavers; the patent should be brought in and cancelled, and the patentees' punishment considered. MR. CREW.—Meantime let precedents be collected of punishment of offenders of this nature, by fine and imprisonment; but if the patentees will voluntarily, in open House, surrender their patent to be called with the Speaker sitting in his chair, with means to make a vacat, then the punishment may peradventure be diverted. SIR THOMAS STROWDE.—As the patent is confessed to have been gotten against the law, there is a course that might be taken against it in the Star Chamber. MR. MIDDLETON.—Sir Thomas would not only kill but flea;—no error was ever more submissively acknowledged in parliament—there was no intendment to use the patent but for the good of all, although I confess there has been some miscarriage in it. The company are willing to yield up their patent. I move this patent may be damned, and an act had. MR. WHITLOCKE.—Speeches are cast abroad, that sitting the parliament we may dissolve what monopolies we will; but after parliament they shall all rise up again.

Patent to SIR LIONEL CRANFIELD to break up houses. The knight was a member of the House, and had voted to punish other patentees. His patent was referred to a committee.

A bill was brought in against a deceitful dyeing of silk. "Dye taketh up one pound in two." The importation of such fabrics was prohibited.

Spanish iron was imported, but the transportation of ordnance was still an unpopular practice. It is obvious, however, that the manufacture of cannon was an improving as well as a profitable one.

SIR ROBERT MANSFIELD.—The Low Countries were armed against us with our own ordnance. It was a common saying beyond sea, that this improvidence was a whip for the foolish English. That formerly one ship in his charge was a match for 40 of theirs—now they claimed to be masters of the sea by our ordnance; the Dutch ships will affront the best of ours. MR. BATEMAN.—We might provide for transportation from Ireland, where good store is now made. MR. JAMES.—The bill that passed last parliament to prevent this had an arrow shot in it, by the proviso that it should not extend to any letters patent granted by the king. Bonds for ten shillings a ton are given under the act by ship captains to bring back the ordnance they carry out. Under the patent these bonds when broken are compounded for forty shillings. MR. HAKEWELL.—All other countries are furnished with our artillery. In Holland there are 1500 great ships, we have not above 500; a true restraint of importation for 20 years would make us again give laws to the sea. MR. FULLER.—Rather than abate the penalty for exporting it, I would add to it, and make it felony. Alluding to the bitter feeling sometimes exhibited in these debates, SIR S. SANDS said, "I have been thirty years in parliament, and more bones have been cast in this one than in all I have known."

Alderman Cockaigne's patent was also the subject of discussion, and it was a remarkable circumstance, that although its operation was most disastrous, both to the factor, to the weaver, and to the country, it was a favourite with the public and with the parliament. Some large cloth factors were, however, opposed to it.

MR. MIDDLETON, one of these, said, "The patentees were like watermen, who look one way but row another; or like sepulchres, fair without and rotten within. The merchant adventurers (who were superseded by the aldermen's company) declared before the council that the project to dye and dress all the cloth was infeasible, but that if it could be done with a pen, or with an argument at a council table, Alderman Cockaigne will do it. His company now has the power to carry out undyed cloths, and also liberty to strain, stretch, and use any manner of slights about the making the cloth, and to ship in strange bottoms! The project at the council table, to bring in 5,000 strangers to dye *all* the cloths, was not to be entertained. We have too great a clothing commonwealth already. Myself and partner maintain above 3,000 workmen, and the Exchequer hath out of our two purses £20,000 a year."

SIR JOHN SAMMES.—The cloth trade is at a stand, because the merchant adventurers and the clothiers are opposed to the patent—but the foreigners gain £700,000 a year by dyeing and dressing cloth, which the patent will save to us.

SIR THOMAS VAVASOR.—The merchant adventurers are no gods, but only impostors; they have practised with the clothiers.

SIR JOHN SAVYLE.—The mischief is great at present, if a course of venting be not had; there are few buyers, and no vent for cloths at any reasonable rate; the clothiers cannot now have so much by £5 in a cloth, and 4,000 or 5,000 cloths are now in town on their hands. Within 10 miles of my house there are 13,000 men set to work; 2,000 of them are householders whose stock is not above £20, many of them have not more than £5, and 300 householders, makers of cotton, are not worth 30*s*. This state of the country cannot endure a month.

The danger was so imminent that a committee of the whole House discussed the proposition of buying up all the cloths lying on the clothiers' hands, "to make a vent" for the surplus stock, to enable the clothiers to set the unemployed weavers at work, instead of abolishing the restrictions which had produced the crisis.

Bernard van Linge, a Fleming, who is supposed to have settled about this time in England, is considered the father of glass painting in its "renewed and improved state in this kingdom." He painted the windows at Wadham College, "the drawing," says Walpole, "pretty good, and the colours fine." Another beautiful window by him is that in the chapel at Lincoln's Inn; other scriptural subjects are in Lincoln College Chapel. His brother, Abraham van Linge, produced some fine specimens, though they are thought somewhat inferior to those of Bernard.

In the beginning of this reign small oval and round portraits, says Dallaway, and about five and six inches by seven or eight in diameter, were much used; many curious specimens of these are still extant in some windows at Oxford.

Aubrey, describing Lord Bacon's villa at Verulam, says, "The glass windows of the gallery were all painted, and every pane with figures of beast, bird, or flower; perhaps his lordship might use them as topiques for locall memory." They were in all likeliehood the manufacture of his own time.

1615. Walter Gedde introduced a great improvement in the art of making leaden window casements: he glazed most of the windows put up in the royal palaces and in the houses of the nobility, during the reigns of Elizabeth and James, and is said to have executed some windows of transcendent beauty, displaying an endless variety of the most elegant and elaborate combinations. Gedde left "draughtes" of 150 of his patterns, from the most simple to the most elaborate.

Gedde, who seems to have been a glass painter as well as a glazier, gives the following as his

"RECEIPETS FOR THE TRUE MAKING OF COLLOURS FOR GLASSE.

"*To make a faire blacke.*—Take the scales of iron and copper, of each a like waight, and put it in a cleane vessell that will indure the fire till they be red hotte, then take halfe as much jeate, and stamp them into smal powder, then mix them with gum water and grind them fine upon a painters stone, and so drawe with it upon your glass.

"*To make a greene collour.*—Take vertegrease, and grind it very well with turpentine, then put it in a cleane pot and warme it at the fire.

"*To make a faire red.*—Take sanguis draconis, and beate it well in a mortar, and after straine it through a linning cloth with aquavitæ, and souse it.

"*Carnation.*—Take two ounces of tynglas and six ounces of jeat, half an ounce of gum, ten ounces of red ocker, and grind them very well togeather, and so use it.

"*Blew.*—Take beades of blew glas, and beat them into poulder in a brasen morter, and halfe as much of goldsmithes blew, amaling that shines through, and grind them together with gum water, and so use it.

"*Yellow.*—Take a quantitie of fine silver, and cut it in small peeces, and put thereto a little antimonium beaten to poulder, and put them togeather in a melting pot, and set them on the fire, well covered round about with hotte embers, the space of an hower, then take it from the fire, and poure into the bottom of a cleane earthen vessell that will abide the heate thereof—after it is colde beate it into fine poulder and grind it on a painter's stone, and when it is well ground, take six times as much ocker as the silver weighes, and seven times as much old earth that hath bin scraped off from enamelled worke; after that let it be well ground; then put all this together in a pot with gume water, and stirre it aboute, and so use it.

"*To make a grey couller.*—Take iron scales, a little cristall, and sum small quantitie of jeate, grind these well together upon a painter's stone; the more jeate ye take the sadder the coullour will be, and likewise the more chrystall you put to it the lighter.

"*To diaper uppon glas.*—Take crystall beaten to poulder, and grind it well uppon a painter's stone with gum water, and so use it; it will apeare a prettie light coullour different from the glas. Keepe this coullour in a little potte, and when you will use it stirre it well aboute.

"*Another faire red cullour.*—Take a quantitie of red glasse beades, and halfe as much of goldsmithes red enamaling, and prepare it as you did the blew coullour before."

Patent to Richard Wrighte, of Oxford, during his "natural lyfe" to imprint the "History of Cornelius Tacitus," translated into English.

1616. Patent. Innocent Lamyer. Conservation of rivers (Thames) to take away shoals and ballast.

Patent. Sir A. Apsley and Sir J. Keyes. Grant of compounding penalties for carrying casks out of the country.

Patent. Sir G. Douglasse. Grant of penalties for "dispensing with the hot presse in cloths." A dispensation to spoil all our woollen fabrics, said Sir Edward Coke, when he spoke of this grant.

1617. Patent. S. Warren, the king's bargeman, the sole buying of all lampreys! This also carried the selling of them.

Patent to FYNES MORRISON, gentleman, to imprint, or cause to be sold, the book called an "Itinerary," written by the said Fynes Morrison, first in the lattyn tongue, and then translated by him into English, containing his ten yeares travels through the twelve dominions of Germanie, the book being first seen, viewed, and allowed by the Archbishop of Canterbury and Bishop of London, or some such other person as they shall appoint.

Patent to NICHOLAS HILLYARD, gentleman, "our principal drawer for the small purtraits, and imborser of our medallies of gold, in respect of his extraordinary art and skill in drawing, engraving, and imprinting of pictures and representations of us and others, which he durst not hitherto show and publish as he can do, for fear his works would be counterfeited by others, and he receive both loss and discredit;" sole privilege for 12 years "within our realme of England, or other places, to engrave and imprint any picture or pictures of our image, and to pay us a yearly rent of 13*s.* 4*d.*"

1618. Patent to RATHBURN and ROGER BURGES for twenty-one years, to print "Maps of London and other places."

Patent to JOHN MARRIOTT for twenty-one years, to print "Pharmacopeia Londinensis."

Patent to HESTER OGDEN, alias Fulke, one of the daughters of William Fulke, Doctor of Divinity, lately deceased, sometime master of Pembroke Hall, Cambridge, "in consideration of the great worth of the books, and the better advancement and maintainance of the said Hester, and of her many children," to print for 21 years two books written by her father. One of these books has recently been reprinted by the Parker Society.

Patent to SAMUEL ATKINSON and SIMON MORGAN, for ten years; "Treasure Trove, finding out things hidden in monasteries."

Patent to THOMAS MIDDLETON for seven years, to print "Brittaine's Blessing." The half of all spurious copies that might be seized to go to the poor of the parish.

Patent to SAMUEL DANIEL, groome of the privy chamber to the queen, for 10 years, to print his "Collection for the History of England."

Patent to JOHN GILBERT for 21 years, "who from his great charge and travel in foreign countries hath invented and found out a new instrument called a *water-plough*, for the taking up of sand, gravel, shelves or banks of the river Thames, and other havens, harbours, rivers, and waters, wherewith they are choked, for the freer passage and safety of other ships and vessels."

Also another instrument for the *raising of water* in greater quantity and to a greater height than heretofore, which is to be driven by a stream of water, or by the strength of horses, and is necessary for the draining of coal pits and mines.

A payment of 13*s.* 8*d.* to be made yearly to the king. Spurious machines were to be forfeited, and Gilbert had power to enter and seize all such to his own benefit.

All treasure trove, plate, jewels, and other things of value as he shall take up by means of the water-plough, one moiety is to go to the king, and the other to Gilbert, "after he shall have appeared in the Court of Exchequer, and made oath to the quantity and vallewe."

Patent to David Ramsey, gentleman, one of the pages of the bedchamber, and Thomas Wildgosse, gentleman, "who at their great pains and charges have found out and brought to perfection divers new apte and compendious kinds of engines or instruments, and other profitable inventions for the good of our commonwealth, as well to plough grounds without horses or oxen, and to enrich and make better and more fertil as well beats, salts, and sellsands, as inland and upland grounds; as also to raise waters from any low place to high places, for well watering of cities, towns, noblemen and gentlemen's houses, and other places, how much soever wanting water, with less charges than ever heretofore; to make boats for the carrying of burdens and passengers, run upon the waters as swift in calms, and more safe in storms, than boats full sailed in great winds, and not heretofore known within our realms." To make them for 31 years, and to pay £10 a year to the king.

A clause was introduced, by which such parts of the patent as were hurtful to the commonwealth might be voided, but remain good in the other part; and the cases of infringements were reserved for the decision of the Privy Council.

The increase of imports and restraints on the home trade continued to produce a general scarcity of money. For the preservation of the bullion, as well as to prevent abuses by counterfeit gold and silver thread, "the king, with the good liking of the inventors thereof," caused the whole work, carried on under the patent to Fowle, to be taken into his own hand, "rather than leave it to the despose and power of private men;" but as his "good care had been interrupted by the importation of Venice gold thread," this trade was forbidden, except upon license. Soon afterwards the importation was wholly prohibited. The resumption of the grant on public grounds turned out to be a manœuvre only; the monopoly was shortly afterwards regranted to Fowle and others, with more unlimited powers than before.

Doctor Egelsfield had a patent for making "gold foliate" only. He had agreed to bring in as much gold as he used. He sold his right for a payment of £200 per annum, and Sir Henry Britayne had an annuity of £50 secured on it also. The patentees were absurdly thought to melt the coin in circulation: the proclamation concerning the use of the gold leaf says, "gold foliate shall not be employed in any building, nor for any ornaments whatever, except for armour or weapons, or in arms or ensigns of honour, at funerals, or in monuments of the dead."

The Flemings in Colchester had been persecuted for many years, when the Privy Council were called on to protect them from the ill-will of the townsmen. In consequence of their resort to it, the town, in 1609, was so full of people that there was not one house to be had there. At this time it contained 1,300 Walloons and persons of foreign parentage.

The Dutch clothiers took great pains to maintain the credit of their manufactures, and had various leaden seals, which were affixed to each piece of cloth, according to its quality. These seals were, as early as 1590, counterfeited by the baize makers at Halstead, and by those in London; and they were also taken off the standard stuffs of Colchester, and affixed to the commoner fabrics manufactured in other towns. The seal made the inferior article vendible, while the quality of the cloth from which it was taken made it saleable in every market without it[a].

Patent. SIR WILLIAM ST. JOHN, for "dyeing stuff, passed to Ginny and Binny, who grievously enhanced the price of dyeing materials."

1619. Patent. SIR WILLIAM ST. JOHN, SIR F. GORGE, SIR G. MOMPESSON.

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[a] The French and Walloons were settled at Glastonbury, about 1549, by the Duke of Somerset, who advanced them money to buy wool, provided them houses and small pieces of land from the domain of the abbey, which had been granted to him. After the fall of the duke they were afterwards protected and assisted by the Privy Council. The number of families seems to have been 32. At Queen Mary's accession they left England and settled at Frankfort; but the woollen manufacture they had established at Glastonbury was carried on for a century after their departure. Other French and Flemings settled at Rye, in Sussex, at Canterbury, Winchelsea, and Dover. Upwards of 400 persons settled at Sandwich, who made bays, which they exported to Antwerp—and when that mart was shut up, they sent them to Rouen and Hamburgh, where the fabrics were not then known. The clothiers who dwelt at Coxall, Braintree, Hastings, and other places, who afterwards made bays largely, learnt the art from these Walloons.

The Dutch who settled at Colchester in 1570, introduced the art of making bays, or as it is now written, baize, an open woollen fabric with a long nap, and also the manufacture of salt. Their industry raised the town from comparative poverty to prosperity. About the same time Dutch fishermen settled at Yarmouth, and improved the art of curing herrings. Five or six years afterwards their numbers had increased so much that the "town," to punish them for enriching it, made certain orders, among which were, that each foreigner should have "only one pink for fishing, and to have three Englishmen to each pink, and not to buy any corn in the market, nor victuals, but for their own consumption!"

In 1572 some Flemings were encouraged to remove from London to Stamford by Lord Burleigh, to whom it chiefly belonged, well knowing what good profit and benefit might redound to the country by the trades and business these men should bring along with them, they being chiefly weavers of such cloth as was not manufactured in England, as, says, stammets, bays, carpets, linsey wolseys, fringes, silks, velvets, tapestries, and linen, figured or damask, or plain;—among them were dyers, rope-makers, hatters, makers of coffers, locks, and knives, steel and copper, and the like, after the fashion of Nuremberg, in Germany.

To trade exclusively to a certain part of Africa, pretending that they were its discoverers.

Patent. JOHN STONE, king's master mason. Stone erected a great number of magnificent tombs in various parts of England, most of them displaying great skill in the management of his materials, and often artistical merit of a high order—a praise, perhaps, that may be shared with the designers.

Sir Edward Villiers, the brother of the favourite, Buckingham, becoming a partner in Fowle's patent for gold thread, put in £4,000 as stock. Sir Edward stipulated to have £500 per annum for himself and £800 per annum for his brother, Christopher Villiers, besides other privileges. Sir G. Mompesson also had a share in this patent. The attorney-general, Yelverton, a lawyer of "infinite corruption," misliking the patent, drew out an agreement between the king and the monopolists, which contained extraordinary powers, and which were speedily put in operation.

1620. The depression of the cloth and iron manufactures, and decay of hospitality in all classes, was considered by the government to be greatly aggravated by the general extravagance in dress—and therefore, "to create a demand for manufactured articles, a bill was drawn up to prohibit persons spending money on fine garments!" "The first clothes," said Mr. Brooke, "given by God were skins, and there were a great many teaches in Scriptures against the vanity of expensive raiment, and a lex sumptuaria was therefore consonant to the law of God and man. Gold and silver stuffs were neither good apparel for summer or winter. They increased the debts, and wasted the estates of knights and gentlemen. Eighteen pounds a year had been spent by a great courtier for shoe strings, and now roses (rosettes?) here cost more than their fathers' apparel. If fashion of dress was settled he estimated that £200,000 a year would be saved to the country."

In the royal estimates a musket, or caliver, with bandeliers and rest, is marked as worth 20*s.* 8*d.* Infantry were armed with calivers and rests, fired with matchlocks; the soldier carrying a line lighted at both ends, a sword at his left, and powder flask, touch box, bullet, and bag, and an additional quantity of match cord. As the wheel did not always succeed, a match was added to it.

For the bye-past thirty years there had been a strong public impression against the policy of allowing English iron ordnance to be exported, and the trade had been repeatedly blamed in every parliament during that period, and two bills had been prepared to prevent it. But the court uniformly disregarded the wishes of the country. On Sir John Jephson telling the Commons that "many pieces of ordnance were lying on the quay to be transported for the Spanish ambassador," the House resolved instanter that a deputation should proceed forthwith to the king, "to stay the transportation of 100 pieces of ordnance destined for the 12 ships preparing in Portugal to be sent against us in the East Indies," and that no one should leave the House until the deputation returned. His majesty did not accede to their request; he said the king of Spain intended to employ the guns only against the pirates—but he promised in future to regulate the exportation. It is most probable that the anxiety abroad to procure English guns was produced by some superiority of manufacture, for at this date the Spaniards were expert iron founders; their wrought iron and steel also were articles the best of their kind in Europe, and large quantities of both were imported into England.

A patent which gave rise to much discussion was that granted to "engross all wills," for 10 years, to Sir Robert Floyde. "It took £10,000 a year out of the pockets of the proctors, who tried to buy the privilege from Floyde, by offering to do all the work of his office gratis, and pay his full fees besides. Floyde refused, and the proctors then got up an opposition. None, they said, by this grant were to engross their own wills but the patentee, who charged three pence a line, and that as short as he could make it, which they considered to impose infinite hardship on the community." To this Floyde replied, that he was no projector, that the patent was granted for the "*reformation* of the exactions of the proctors."—That he engrossed for *5s.* what they charged *£5* for—that the proctors maintained by their counsel, that if a man engrossed his own will he must pay *them* for it, but he did not advance this claim, and none complained but the proctors. Floyde was an unpopular, hard-mouthed man, who had, moreover, offended the king by some foolish expressions he applied in conversation to the Elector Palatine and his wife. During the debate a court member gave the knight "a lick," by stating that he heard his majesty at Hampton Court inveigh more against this patent than any other. Sir Robert Naunton, the secretary, who had acted as referee, was accused by the House of having advised the king to issue the patent. The secretary, with infinite effrontery, solemnly denied the charge, but Sir Edward Coke stated, that to *his* knowledge Naunton *did* recommend it. Floyde thus qualified to be a popular scape-goat, being called in, and made to kneel at the bar, was told by the Speaker that his patent was a grievance and void, and that he was no longer a member of parliament.

The following patents were among the number of those ordered by parliament to be brought to the House, and their holders to attend and be examined:—

The patent of "rogues and licensed pedlars."

Patent "relating to apprentices;" reckoned by the freemen a great injustice, but which was calculated to be of great benefit to trade.

Patent for a light-house at Winterdoness. "The expenses were about £350 a year. A toll of six pence a ton from all ships passing it would not, it was stated, pay for the light."

Patent for a light-house at Dongeonesse. Coke thought this and the preceding patents "should have been granted to persons of skill only, but they were performed by deputy, and that helpeth not."

Patent for returns to Sir P. Saltonstal.

Patent to Hill, for "scouring arms throughout England," granted for Mr. Sheldon's use. "Abraham Gray gathereth much money in Yorkshire," said Noy, "for dressing and cutting of arms; cutteth divers corslets, and marreth them; sendeth for poor people to bring their arms 10 miles; makes above £600 a year in Yorkshire." Gray was "sent for" and payment of money stopped.

Patent to Burnet for "customs."

Patent to Endymion Porter—"forfeitures." Porter was one of the attendants on Prince Charles and Buckingham during their visit to Spain.

Patent to Chambers for "collection of forfeitures;" a most lucrative and comprehensive privilege.

Patent to Sir A. BRITAYNE, to make warrens and parks. "A flower of the crown," said Coke, "never before made merchandisable; none should grant regalities but the king. Of the fine, 20*s.* went to the crown and £30 to the patentee."

Patent to Sir H. BRITAYNE, to dispense with tillage. "He can make a park; now," said Coke, "he can dispense with tillage and convert it to sheep." Britayne gave £1,000 to two persons attached to the court for the privilege. Bacon and Yelverton were the king's referees.

Patent to Sir H. BRITAYNE, who seems to have been a wholesale patentee for a new invention of hard wax; but it was an old grievance, said the House, to imprison men for breaking it.

Patent to Sir A. TOWNSEND, for concealments. He had "mulcted 17 hospitals, and was going on to squeeze others."

A patent for the sole making of iron ordnance was held by one Brown, who made and exported the ordnance on his own account, apparently with the sanction of the court, if not by its order, but against the expressed wish of the commons and the public. The merchants did not export 300 tons a year. Brown, it was now alleged, had Dutchmen in his employment, to teach them the art of casting artillery, though most likely they instructed him. His cannon were in great request, but his exportation of them made him in ill favour with the House, and his patent was voted a grievance. Another patent for the sole making of ordnance was granted to John Crowe, that of Brown being soon to expire. He was tied, for appearance sake, to export none, but bring all he made to the Tower, at £12 a ton; to have but two furnaces, and to be responsible for any ordnance that was exported. The popular delusion on this point was so great, that one of the anti-export members, Sir Thomas Row, said, "Formerly there were only two furnaces for making ordnance, called the king's furnaces. This is an honest patent, to have but two furnaces and a great stock of ordnance."

A bill was read to restrain its exportation, and to hinder its transportation into Scotland; until a law was made *there* making it felony to carry it thence beyond sea.

Sir Robert Mansel's patent for making glass of sea coal was several times discussed and strongly opposed. The committee, through Sir E. Coke, reported that "the consideration failed, for it was proved to be no new invention—the invention was only of making new furnaces, and thereby gave no power for the sole making of glass, and should not exclude making of glass by charcoal, but only by seacole. One patent for making glass was condemned as a grievance last convention of parliament, yet Sir Robert Mansel shortly afterwards procured this new privilege for 21 years—the term is too long—and the restraint of importation is wrong. It was doubtful, continued Coke, whether glass is so good as before, and Enego Jones, the surveyor, says, glass is not so good now as in ancient times, and he thought it dearer than before the patent. The £1000 per annum reserved to the king had not been paid." In Coke's opinion the grant was a grievance in creation and execution.

This was the parliamentary, but one-sided view, of Sir Robert's great improvement. From the scarcity of wood fuel, the glass trade, as well as the iron trade, must have been abandoned had pit coal not been introduced, instead of wood into the manufacture. The prohibition objected to by Coke was of "all foreign glass, excepting that of *inferior* kinds." Sir Robert had the privilege of importing drinking vessels and every other glass article from Italy, which were there made of a finer quality than in England; and he was bound to sell them at moderate rates. Howel, the well known author of "Londinopolis," when a young man, was, for a year or two, steward of Sir Robert's glass-house in Crotched Friars; "but had I continued there," says he, "I should in a short time have been melted away to nothing among these hot Venetians, finding myself too green for such a charge." He was sent abroad by Sir Robert to engage some skilful workmen; and in 1621 he writes from Venice to Sir Robert, that "the two Italians who are the bearers of his letter are the best *gentlemen workmen* that ever blew crystal. One is called Antonio Miotti, the other is cousin to Mazalao," who was already in London. In another letter to a friend, dated from Venice, he notices the Venetian opinion of glass blowers.—"The art of glass making here is very highly valued, for whosoever he be of that profession are *gentlemen* ipso facto; and it is not without reason, it being a rare kind of knowledge and chemistry to transmute dust and sand, for they are the only main ingredients, to such a diaphanous, pellucid, dainty body, as you see crystal glass is. They have a saying here that the first handsome woman that ever was made was made of Venice glass, which implies beauty but brittleness withal, and Venice is not unfurnished with some of that mould, for no place abounds more in lasses and glasses."

Notwithstanding the monopoly Sir Robert Mansel and his partners did not make this a profitable speculation. "He has melted," says Howel, "vast sums of money in the glass house, a business indeed more proper for a merchant than a courtier. I heard the king should say that he wondered that Robin Mansel, being a seaman, whereby he got so much honour, should fall from water to tamper with fire, which are two contrary elements." Although he had Italian workmen he did not succeed in making glass that could compete in quality with the Venetian[a].

Patent to Sir I. APSLEY and SIR I. KEYS, to license exportation of casks, a beneficial but very unpopular grant.

Patent to JACOBBS, for garbling tobacco.

Patent to WYNELET, for importation and exportation of cards.

Patent to Sir T. COMPTON, for importation of logwood, which was prohibited. Great complaints were made against the dyers for using this "deceitful stuff." The patent was ordered to be brought to the House "by Jarvys, of the Customs, who excerciseth the same."

Patent to EGELSFIELD for gold foliate. "Cutlers used to buy gold for 20*s.* which is now 30*s.*, and it is enhanced to painters and bookbinders also. The leaf is made thinner, worse, and less;" but the thinness of the leaf was the effect of an improvement in the manufacture. In the queen's reign the gold beaters were everywhere used to beat the gold leaf between skins of parchment. About the time of King James's accession, the German gold beaters are said to have introduced into the process the fine gut of an ox or cow, instead of the thick parchment. In 1621 Mersenne astonished the public, by showing that the Parisian gold beaters had the skill to beat an ounce of gold into 1,600 leaves, which covered a surface of 105 square feet. English foliate was, perhaps, no thinner than this, and the complaint against the patent foliate, as well as the German name of the patentee, marks, most likely, the introduction of the gut skin into the English workshop. 90 years after this Reaumur found that an ounce of gold was then made to cover 146 square feet, and now it is made to cover a greater area, so that although Egelsfield's foliate was not so thick as that made heretofore, it was a half thicker than that made now, and substantial enough for most purposes.

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[a] During the debate on Sir Robert's patent Sir Charles Morrison "fell into an old rhyme about asses and glasses, and being out of it, he asked Mr. Glanvyle, who sat next to him, how the rest was, and Glanvyle thereupon repeated the two last verses." "Young Coke," who was sitting near, "took it ill, the mentioning of judges riding on asses," and struck Sir Charles; both were taken into custody. Glanvyle, who sat *between* the quarrelling members, being examined, stated that it was *he* that spoke the offensive rhyme, which Sir Charles had forgotten. "Besides," said Sir E. Sands, "Mr. Glanvyle, who repeated the verses, is a judge's son, as well as Mr. Coke, and he was not offended; and the rhyme is near true, for in my memory the judges rode upon mules." The venerable Sir Edward refused to become bound for his son's appearance. "I love him," said Sir E. Sands, "in his person, and thrice for his father's sake, but I vote that he be committed." Coke the younger was thereupon called in, and knelt at the bar, and the Speaker sentenced him to be committed to the Tower. A day or two after he sent a submissive petition to the House, and Sir Edward made a motion in his favour. Out of respect to his "great father" he was liberated from prison, but to remain in his charge until his offence was investigated."

Patent to LEPTON for making of bills. He gave £10,000 for the privilege to the lord president.

Patent for "pins and shreds."

Patent for "printing linen."

Patent to BASSONO and VAWDREY for 31 years, for sole importation of lobsters, on pretence of a "new invention or discovery of the fish beds;" "but the king's subjects," said the committee, "went to the same spot five years before. The time granted is too long. The patentees meet the Dutch, and bring here what they buy from them, which is plain forestalling; a lobster formerly one penny now three pence.' "The patentees," said Coke, "took away the fishermen's goods; some who took away their horses by replevin were hanged."

All the preceding patents were condemned by Coke and his committee to be "grievances in original and execution, and to be void in law."

1621. The scarcity of money and bullion kept public attention fixed on the gold wire drawers, as destroyers of gold and silver; and the making of gold and silver thread, as a great waste of bullion, was repealed by proclamation; but it being found that a great many *lived by the trade*, it was suggested to form the craft into a corporation, which should be bound to control the waste, and import all the gold and silver they melted.

The exportation of gold and silver continuing, money became so scarce that tenants who had corn and cattle enough, being unable to sell them, gave up their farms. Land had fallen from 20 years' purchase to 13. Labour was of little value;

the wages of clothiers and weavers were only three pence a day, and great numbers were idle; fairs and markets were at a stand, and trade was so depressed that in one town 200 looms were laid down, each of which maintained 30 persons."

The supply of coin was stated to be the principal reason for calling the parliament. The king desired the Houses to consider trade, and the means for making it better; and "show me," he said, "the reason why my mint for these eight or nine years hath not gone."

Coke, Sands, and Strowde, ascribed the scarcity of gold and silver, and consequent public distress, to prodigality in apparel, "serving in silver, excess of silver plate, the show of twenty goldsmiths' shops in Cheapside being the greatest in Christendom; the manufacture of gold and silver thread in the country, which consumed £20,000 of gold in a year; of gold foliate, which wasted £4,000 in a year," although less of both thread and foliate had been made during the last seven years than before; goldsmiths melted coin into plate. The East India Company carried bullion out of the country, and since their patent little had been seen in it. To these popular causes the merchant members added the importation of an increased quantity of French wines, and large quantities of French linens and cambrics, and £120,000 worth of tobacco. A great number of Irish cattle had been brought over; 6,000 had come last year to Chester alone, and nothing carried back but money. 200 Newfoundland ships were victualled in a year there, instead of in England, and their wools, not half the price of wools in England, were carried abroad. The general cause of the distress being that more commodities than before had been brought into the country, and fewer had been exported, and the exportation of money could not be restrained until the trade was balanced.

Coke said between 1558 and 1612 upwards of nine millions and a half had been coined at the mint; but for the last nine years £10,000 had not been minted. The House referred the inquiry to a committee, who reported the scarcity came from unequal balancing of trade, export of silver by the East India Company, and importation of tobacco; the latter article added, perhaps, to please his majesty. One of the first remedies, however, said Coke, for this state of things was to "sweep the House of monopolies and patents."

To save, in appearance, his honour, if not also to mask the indirect participation of those about him in the gains of patents of monopoly, it was the king's practice, when applied to for a grant, to refer the petition to some of his law officers and members of the privy council, to investigate the grounds on which the patent was solicited, and to certify whether or not it should be issued. So far, however, from these *referees*, as they were called, being a check on the growing corruption, they much increased it, and in one way or other profited greatly by it themselves. Their pretended scrutiny and their recommendation gave a weight and authority to the monopoly claim which in the eyes of the public it did not possess before; one of the effects of which was that the patentees and their agents proceeded, in a more open and shameless manner than heretofore, to practise "against all law and usage" their extortions on the country.

The committee of grievances, inquiring into the evils of these grants, condemned, in an especial manner, as bad both in origin and operation, the patent "to reform abuses in several innkeepers and alehouses, and to compound for the penalties of obsolete laws in the price of horse meat," which had been granted to Sir Giles Mompesson, Sir Francis Mitchel, and others. Sir Francis Bacon, the lord chief baron, the judges Nichols and Croke, Lord Suffolk, Secretary Winwood, had been the king's referees; and the committee passed the same judgment on the patent to manufacture gold and silver lace, which had been granted to Fowle and Dykes, and Sir Edward and Christopher Villiers. Mompesson, a partner in this also—a general dabbler in such things, and a member of parliament, on the report of the committee being read, admitted being the projector of the patent for the regulation of inns and alehouses, (though "one Milton," who could not be found, was its original contriver,) and he professed his willingness to make satisfaction for anything he had done amiss, and stated that he had done this several times to those he had unintentionally injured. When he withdrew, Mr. Pym thought the decision should be deferred, as Sir Giles was charged with divers "other patents and faults;" but Mr. Wentworth said, to give him time was to give him life, and that he ought to have had no patent if the referees had done their duty; and before the matter went further he moved that Sir Giles should be sent for, and made secure, and in the interval that the door should be locked, that no member should leave the House until he came. When the knight arrived he was formally placed in custody of the sergeant-at-arms.

Sir Giles expressing an anxiety for his papers, and the officer thinking he could not have them without going home, agreed to accompany him thither. There he found Sir William St. John and a party of ladies, who shortly after were joined by two members of parliament. Sir Giles (and his attendant) being in the dining room with his company, contrived to make himself sick with tobacco and sack, and "cast in the room as if he would heave his pluck." He spoke to his wife to attend him into his closet, and the sergeant thinking it unmannerly to follow them, remained with the ladies, and enjoyed himself for an hour or two; then craving leave to depart, he desired Sir Giles to be told that he waited his pleasure, but the knight was nowhere to be found; the prisoner had escaped. His papers and books, and the house in Wood Street, in which he carried on his gold thread trade, were next morning seized by Parliament. His partners, Fowle, Dykes, and Sir Edward Mitchel, a member of the House, were sent to prison, to abide the result of an inquiry into their proceedings.

It had been resolved, that if any member of the House should be a projector or protector of any patent, that he should be expelled from the House. Mompesson had admitted, by letter, that the brothers of the favourite were partners in the obnoxious patents, and the agreements were in existence. Sir Edward Villiers had been charged by Sir Robert Phillips with having threatened some who resisted his monopoly with perpetual imprisonment, and the Villierses were so generally reprobated as greater harpies and delinquents than either their fugitive or their incarcerated partners, that the marquis himself found it necessary, in his place, to disclaim having any sympathy for his brothers. "For his own part," said he, "sithence he had been righted here, and that now he knew the wisdom of parliament he would submit himself as a scholar to it. That two of his brothers were drawn in question. He would not defend them, but leave them to the censure of parliament. He that begot them had begot one who would seek for their punishment."

Sir Edward Villiers during these discussions came to the House as usual, and not only attempted to excuse himself, but found a member to speak in his favour, and make a distinction between a projector and the plunderer. "Sir Edward," said his apologist, "was *only* a sharer and adventurer." Although the House had sent three of his partners to prison, so great was its fear of the favourite, or as Sir E. Gyles expressed it, "its fear of casting stones," that after a debate on a motion to exclude Villiers from his seat, it was abjectly concluded to intimate to him, "that it was left to his discretion to come if he will!"

Parliament then commenced inquiry into the complaints against the patentees. They were found to have issued warrants in the attorney-general's name, to seize and imprison. Mompesson had committed several to gaol without examination, and had threatened others with imprisonment. Fowle had locked up several persons for days in his own house, and some tradesmen had been confined for weeks. They had broken open houses, seized goods, compelled many to make oath what quantity of gold and silver thread they had sold, and to whom, and had bound over craftsmen of eleven different trades from the use of their callings. They had falsified the manufacture by mixing gold and silver thread with lead. They had imprisoned many innkeepers, who after petitioning the king, compromised with the patentees, by paying them £2,000 a year. 9,000 recognizances had been returned to the Crown Office, and several cloak bags were filled with others which had been certified. They had put 40 and 50 names in one writ, and one process writer, at a penny a piece, made £200 a year by them. The lord treasurer in nine several papers had given allowance to these proceedings. The patentees, however, had *not* exceeded the strict letter of their grants; the powers given to them under the great seal were excessive. Lord Arundel said these were granted and meant to be *rarely* acted on, but they had been used familiarly, to the undoing of thousands.

Mompesson, who had escaped, was sentenced by the Lords to be degraded from knighthood, perpetually outlawed, exempted from all general pardons, not to come within twelve miles of the court; when captured to be imprisoned for life, fined £10,000, disabled to hold office under the king, and to be for ever infamous.

Sir Francis Mitchel, who, according to Wilson, "was a poor sneaking justice of the peace, that lived among the brothels in Camberwell, and maintained himself by contributions raised in that neighbourhood," was degraded from his knighthood, expelled the House, and kept in prison during the king's pleasure in the "same chamber which he had provided for others, the Tower being too worthy for him," and fined £1,000. Fowle and Dyke were also punished.

Buckingham, when excusing himself for not being present when sentence was passed, said Mompesson had grievously deceived him. He "commended the trades that employed so many persons; and if bullion was brought in, and care taken that the thread was not sophisticated, a new patent, if granted, might be gainful both to king and commonwealth!" The Prince Charles condescended to applaud the proceedings against the patentees, and the king said, "Now I begin to find myself a free man, by the freedom from importunity of suitors upon the stifling and judging of patents, and Buckingham told me he never found such ease and quiet as in this time of parliament from projectors who miserably vexed him at all times. I am ashamed, and it makes my hair to stand upright, to consider how my people have been vexed and polled by the vile execution of projects, patents, and other such like, which have more exhausted their purses than subsidies would have done. I have already freed the persons that were in prison. I will now damn the patents; my purpose is to strike them all dead, and I will recall all three by proclamation." To the sentence of parliament on Mompesson the king said, "I add perpetual banishment."

The House of Lords having by this just sentence expressed their detestation of acts of gross plunder and oppression, proceeded to the investigation of the charges against Sir Edward Villiers. Having mulcted Mompesson, and thrown his partners into prison, and rendered all of them for ever infamous, and by this means having made them scape-goats for the premeditated outrages of the king, the referees, the favourite, and his relations, against the property and liberty of the lieges, they wound up the solemn farce of dispensing justice by declaring Sir Edward Villiers, the chief, the most active, and most rapacious member of this band of extortioners, to be innocent of the offences that had been charged against him.

Sir Henry Yelverton, who had drawn up the grant, was also accused. In his defence he denied the manufacture of gold thread to be a monopoly; and during his speech reflected with some bitterness on Buckingham. The Lords sentenced him to pay a fine of 10,000 marks, and be imprisoned during the king's pleasure. For scandalizing the Lord Admiral they further condemned him to pay 5,000 marks, and be imprisoned until he made the marquis an apology. The king and Buckingham forgave the fines and imprisonment, and no further censure was passed on Sir Henry, on account of the complaint of the Commons. This adroit and corrupt tool of the court was afterwards reconciled to Buckingham, and made a judge of the Common Pleas.

Patent to JOHN LEGATE, to print "Thomas's Dictionary, granted at the suit of John Legate, and of ten other, his brothers and sisters, who say, that their late father augmented that book, and has left little else among them for their education and advancement, but the benefit accruing by the printing of it." They surrendered Thomas's patent, and another was granted for 21 years from this date.

Patent to JOHN SPEEDE renewed for 21 years; "his estate being much weakened, and for the better reliefe and comfort of himself, now aged and sicklie, and of his wife and manie children."

Cornelius Vermuyden, an expert man in the art of banking and draining, undertook to drain Dagenham Marsh, and in recompense of his charges had parcels of the recovered lands assigned to him.

Two or three years after he undertook to drain Hatfield Chace, containing 72,000 acres, which were covered with water, on condition of receiving a large portion of the drained land. Upwards of 200 Flemish families settled on these levels as farmers. Vermuyden brought a number of workmen from Holland, and machines for draining, and when the ships containing them were sailing up the Trent, they were facetiously called the "Navy of Tharshish." He was supported by Sir Philibert Vernatti, Andrew Bocean, the Volkenburgh family, the Vanpareens, and John Corsellis, and by the king. His operations did not give satisfaction to the natives, though he gave much higher wages than had been given before, and made liberal allowances to those who suffered by the change.

A large proportion of the extensive district draining, or what was called "inning of marshes," performed about this time, was done by Dutch speculators, with money advanced by their rich countrymen.

1622. Aubrey, in his history of Surrey, states that the manufacture of tapestry which was set up at Mortlake, near London, by Sir Francis Crane, was commenced in the reign of Charles I. The honour arising from its introduction belongs, however, to James I. A letter written by Sir Francis to this prince gives us the first account of the state and prospects of the undertaking:—"I beseech your majestie," says Sir Francis, "that the reasons which have begott this boldnesse may excuse it, which are these;—I cannot thinke but that your majestie affects the continuance of the business of the tapestries, which in the eye of the worlde appears as a worke of your majesties greatness, and bringes with it both honour to your majestie and profit to the kingdome. The prince and my lord marques both, (to whom a little before their journey I represented my necessities and the impossibility of continuinge the work, unless I were assisted in it,) gave me commandment to keepe the busynesse afoote, and promised me for the present to keepe the fire goinge (which was the prince's own phrase); that I should instantly receive the money laid out for my lord marquis, which was £3,200, and that I should have the benefit besides of two sergeants. The prince gave me an order to goe in hand with a riche suit of the moneths, and to send to Genua for certayne drawings of Raphael d'Urbin, which were desseignes for tapestries made for Pope Leo the Tenth, and for which there is £300 to be paid, besides their charge of bringing home. Now, sir, here is my case; I would not fayle, if it lay in my power, in the performance of any thinge thus affected by your majestie, or commanded by them; but I am out already £16,000 in this busyness, and never made returne of more than £2,500, so that my estate is wholly exhausted, and my credit so spent, besides the debts that lye upon me, that I protest unto your majestie (before Almighty God) I knowe not how to give continuance to the busynes one moneth longer, which I durste not but acquaint your majestie withal, because if the course intended by your majestie will not provide for it before that time, and that the busynes be dissolved, I may yet stand justified in your royal majesties judgement, that no endevor of myne hath been wanting, either to serve your majestie, or to obey those commandments that I hold equal with the life of your majesties most faithful and most obedient subject and servant."—FRANCIS CRANE.

This letter appears to have had the desired effect, for in 1623 Prince Charles wrote to his council from Madrid, directing them to pay £700 for some drawings for tapestry, which he had ordered from Italy, and £500 for a suite then making for him at Mortlake by Sir Francis Crane, and which he earnestly desires may be finished before his return.

Two years after this he acknowledges being indebted £6,000 to Sir Francis for suites of gold tapestry, and as a settlement he granted him an annuity of £1,000; and for the better maintenance of the manufactory, a further grant of £2,000 yearly for 10 years.

Some tapestry was produced here of very great beauty and value. Williams, Archbishop of York, paid Sir Francis £2,500 for a set called the "Four Seasons." Another set, called the "Five Senses," was in the palace at Oatlands; some of the cartoons of these are at Hampton Court[a]. At Knowle is a piece of the same tapestry wrought in silk, containing portraits of Vandyke and Sir Francis himself.

The buildings were of considerable extent. In a survey made by order of parliament, the tapestry house is described as containing one room 82 feet in length, 20 in breadth, with 12 looms; another 41 feet long, with six looms, and a great room called the "limning room."

How long Sir Francis conducted this manufactory does not appear, but it was not relinquished at this period through want of royal patronage, as has been stated, for costly suites were made at Mortlake twenty years after the date of the grant by King Charles.

The king issued a special commission to survey the name, qualitie, and trade of aliens. Those who were wholesale traders were to make an annual payment or quarterage to his majesty, that "it may appear they enjoy their freedom, not as right, but of his meere grace and favour." No stranger born in England, who had not been seven years an apprentice, was to sell any article by retail, nor by wholesale, at fairs and markets out of the town where he dwelt. Those doing this were to "alter their way of life, which doth so apparently tend to the depauperation of the English shopkeepers;" and as "by law they ought not to use trades but as servants to the English," they are invited to enrol themselves servants to the king, and as a thankful acknowledgment for his royal favour to pay him a portion of their earnings, "to be disposed of for the ease and comfort of his own people, whereby his natural born subjects may discern he puts a proportional difference between them and the strangers, sufficient to give them encouragement, if their own want of industry and honest workmanship be not the impediment." Masterless men of handicraft trades were speedily to return to their own country, or put themselves to work as "*hired* servants."

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[a] This was sold in 1649 for £270, about a fourth of its value. Sir Francis was the last lay chancellor of the Order of the Garter. He had the grant of an estate at Stoke Bruerne Park, in Northamptonshire, in consideration of money due to him from the crown; on which he commenced in 1630 to build a house, upon a plan which it is said he procured from Italy, and in which he had the assistance of Inigo Jones. At its completion he received a visit from Charles I. and his queen. He became an adventurer in the fen-draining speculations, and held 3000 acres in the Bedford Level. In 1635 he went to Paris, and was cut for the stone. It is said he died at Stoke Bruerne in the 82nd year of his age.

Yet for the "encouragement of all strangers to bring new and profitable trades into practice, which have *not before been used* by any of our own people, whoever shall instruct therein any natural born subjects who are meere English may without restraint use such trade for ten years after coming into the realm;" but no alien was to retain more than two journeymen, nor have any apprentice, except under lease for seven years.

At the date of this commission the finest woollen and silk fabrics of all kinds were made in general by the refugee workmen. The trade during the last 12 years had rapidly declined, not only from injurious restrictions in favour of the home trade, but from the quality of the staple being depreciated, so that the dyed cloths exported under licenses could not compete with those of Flemish and German manufacture; and the unemployed clothworkers complained to parliament that the merchant adventurers, also, who had the sole exportation of white cloths, did not set them to work.

The commission, notwithstanding, thought that by discouraging the immigration of foreigners the native workmen would be benefited; considering the depression to be solely produced by a want of market, and that not a result of the lower quality of the market article itself. The way formerly tried to better a similar state of things was by inviting and encouraging foreign workmen to settle in England, as they necessarily brought with them the knowledge and practice of the most improved processes, in which the English had only a deficient skill. There is no instance, however, in which this encouragement of foreign artizans did not excite the resentment of the native workmen, "as a taking of the bread out of their mouths," and the commission now pandered to the popular prejudice.

While the House was engaged in the condemnation of patents, a bill regulating monopolies had been introduced. After a long debate on the time for which a patentee should be allowed the sole use and profit of his invention, the term of 14 years, which had been inserted in the draft, was reduced to 10 years. The bill passed with this amendment, and was carried to the Lords, who rejected it at the first reading, "because they were drawing up a bill themselves." At a conference of the Houses shortly afterwards, a memorial, or heads of a new bill, were agreed to. All patents for monopolies were to be abolished, saving privileges for years for any thing newly invented; and persons soliciting an illegal grant were to incur a *præmunire.*

It should be remembered that Coke, who drew up the bill that the Lords discarded, had declared that "he was against all new inventions and projects," and that "free trade was a great prejudice to the commonwealth." From the whole tenor of his opposition to the patents, as they were discussed seriatim, it might be inferred with perfect fairness, that had the House been guided solely by his judgment, letters patent for inventions would have been abolished altogether. With regard to the patents for forfeitures, Coke said the committee "never meddled with the king's power to dispense with a penal law, but only against its transfer to another that hath not a regal mind."

Patent to THOMAS MYNNE, Esq., to dig for all manner of mines, and ewers of gold and silver, within the town and parish of Narbury, in Stafford. "Mynne had authority to call before him all persons that he might think meet, and examine on oath, or otherwise; and to take up at reasonable wages and rates, all such artificers, wood, tooles, instruments, and stuffs, as he required."

The Commons had pursued their course with great perseverance, but their firmness had made little impression on the court, for during their "judging and stiffling of patents," as their proceedings against the patentees were called by the king, he granted a patent to SHARPEY AND HEDLEY, for a "survey of seacoles," which was worth £3,200 per annum.

Some of Sir Ferdinand Gorge's patents had been reprobated by the committee, and Coke described one of them as a "monopoly of the sun and wind." During the recess, however, Sir Ferdinand, in conjunction with SIR JOHN BOWCER, had a patent granted to them for the sole fishing on the coast of America, pretending that they had discovered the fishing grounds; and two months afterwards they had the temerity to ask for and enforce admiralty warrants to arrest five ships at Plymouth and two at Dartmouth, and prevent their sailing to fish on the coasts of New England.

This patent some months after was called before the House, and condemned, and the Commons petitioned the king "that the patent, so far as related to free fishing, should be utterly void and never hereafter put in execution;" the right of fishermen to visit the coasts was yielded.

1623. At the opening of Parliament, when the Speaker, after his election, addressed the king, he spoke of the bill of monopolies, and "hoped it would be perfected." The king replied, that "what had been the occasion of dispute between him and former parliaments was their jealousy of him. Take away that, and nothing can do you harm—you are my wife, and jealousy is subject to a wife, therefore remove it, and be not jealous of me, and let not any stir you up to law questions, debates, quirks, tricks, and jerks, but continue yourselves in that honest modesty whereby you may procure the love of me, and a happy end to this parliament."

To neutralize, if he could, the effect of the Commons in discussing the grievances under the patents, the king, in a proclamation, says, that "his own ears, and those of his privy council, are open to the grievances of his subjects; and calling to mind the many complaints that were made in the late convention of parliament against monopolies and other like patents, he had appointed the Marquis of Buckingham, the Earl of Arundel, and two bishops, to receive the petitions and complaints of his loving subjects, and deliver them to him, or to his privy council." The object of this was to open the mouths of the patentees against the tyrannical conduct and decisions of the parliament. No one, however, who was aggrieved by an imposition was likely to make complaint to the commissioners, for the name of the great abettor of the evil was that placed first on the list.

A new method of dressing woollen cloth is forbidden. "Of late years," says the Act, "divers subtle and naughty means and devices have been practised for the pressing of woollen cloth, by the heating of thick boards or planks, and laying the same under and above the cloths in the cold press, and also thin or ceiling boards and pasteboards, made very hot, are put into the cuttles or plates of cloths, and then put presently into a cold press, and divers other cunning sleights, by which chapmen and buyers are deceived, and the woollen cloth of the kingdom is disgraced, to its great prejudice and scandal." All pressing by or with heat of fire is therefore to be punished as pressing with a "hot press" is punished by former statutes. And no tenter was to have any chase under it longer than 4½ inches.

Innkeepers used to bake horse bread, and charge what they chose for it, to the great annoyance of the travelling public, who complained of its price and quality; now they could only bake it where there was "no common baker within the limits of their houses." The dealers in butter and cheese were also restrained from selling it in greater quantities to one person at once than four wey of cheese, or four barrels of butter, to prevent forestalling.

Patent to George Withers, gent., for 51 years, to print the "Hymnes and Songes of the Church." Price of book to be regulated by the Company of Stationers.

1624. A bill passed to affirm a judgment given in court for revoking and annulling the patent to R. Heron, for drying and packing fish in Devon and Cornwall; and Lord Montgomery, in the House of Lords, delivered the letters patent to be cancelled. The patent was issued to Heron, for the use of William, Earl of Tullibardine. On this surrender the Lords moved that some other reward should be bestowed on the earl, as the grant which had been given for services had in no way been beneficial.

The parliament during this session called for the patents of the Merchant Adventurers, the most wealthy and powerful body in the kingdom, "in order to have some breviate made of them."

The Eastland Company, who had the importation of all articles necessary for shipping, "howled with the wolves" on this occasion, and when their patent was sent for they were so submissive as to be praised for their "carriage."

The patent "for the East India Company" was examined at the same time. The company were charged with producing the scarcity of money by their exportation of bullion.

The operations of the corporation of gold wire drawers were considered by parliament to increase the scarcity of coin as much as Mompesson and Mitchel had done, and their patent was revoked. The manufactures of gold and silver thread, gold and silver foliate, purles, oes, spangles, are declared to be *unfit* to be continued in the realm, and therefore the king is resolved to abolish such manufactures.

Patent to Richard Johnes, for soap, "was petitioned against by the soapers." Johnes had introduced some improvement into the making of it.

Patent to Nicholson for pretermitted customs. "He brought in his patent, and was ordered to attend die in diem, and a search to be made for precedents of punishment of such offenders." A bill was brought in against him as projector of the grievance.

During the passage of the bill to demolish patents, the king issued two grants to Dorothy Stewart and Robert Stokes, to sell letters of naturalization to foreigners.

Sir John Townsend's patent was condemned, says Coke, in the last parliament, yet he proceeds upon it.

Another had a patent for the sole printing on one side, who had often been warned to bring it. "The sergeant-at-arms was sent for him; and he was ordered also to fetch Withers, (the poet,) together with his patent. The sergeant's man, who took Withers, stated at the bar that he was withstood and abused by one at whose house Withers lay. Withers, however, assisted him, and kept him from wrong;" the person who had the keeping of Withers's patent was ordered to produce it; the patent to Mynne, and the patent to the woodmongers, were also demanded; the patent, granted to Sir William St. John and others, for the sole trading to some parts of Africa, was found surreptitiously gotten. The patentees with consummate assurance desired to have "a patent for three rivers discovered by them," apparently under the sanction of the House.

Through hardness of times and hardness of hearts the cloth-workers were in great distress, but the government, who were driven by the party who advocated the exclusion of foreign manufactures, and prevention of exportation of unfinished cloths, when so many native workmen were without employment, were solicited, by the clothiers themselves, to allow exportation of a quantity of undyed or white cloths, and that other merchants besides the merchant adventurers should trade with dyed and dressed cloths. The inconvenience occasioned to the market, and hardships inflicted on the workmen, by the prohibition, were well seen in some practices which the committee denounced as grievances. The alnager, said Coke, "stretched his office upon stockings, waistcoats, and caps made of wool, pressing retailers to have their cloth sealed, after the clothier had sealed them," or rather, as he ought to have said, the legal sealer pressed the retailer to have the true seal put on cloths to which a false seal had been affixed.

There was little of the best cloth to alnage, and its seal, which had been an instrument of right, had become now one of deceit; seals were sold at a penny a piece by bushels. There was no vent for the woollen staple, the cloth-making community was idle and starving, and there was no coin in the country, even for the common demands of domestic trade; yet Noy said in the House, "This session we have made it felony to export wool,—shall we extend it to cloth?" His opinion was that they should.

At the end of the session the House ordered that "all patents which had not been examined nor condemned" should be re-delivered to the parties that brought them in.

Thirty members went up with the Speaker to present to the King the petition from the House against monopoly patents, to whom his majesty replied—

"Now I speak to all of you,—be not too ready to hunt out grievances where there is no cause. I find most of them to be slight ones, which indeed makes my heart jovial. Be careful to present such as be general towards the commonwealth, and as it lies not in your power to raise and create grievances but upon just cause, so again you ought not to conclude and determine without letting me have the hearing and allowing of it; and touching my patents in general, I am grieved you have called them in and condemned them upon so short an examination. I confess I might have passed some upon false suggestion and wrong information, but you are not to recall them before they have been examined by the judges. And here I have heard it complained of by divers of my learned counsel in the law, that you will from time to time, delaying the patentees, still call for patents without just ground, and so put the subjects to much charge, and so a scorn upon my patents. I therefore advise you to be careful that you have a good ground before you call for patents, and that you do not defraud the patentees. Hereupon falls out that which I spake to the face of many here present; the lawyers, of all the people of the land, are the greatest grievance to my subjects, for when the case is good for neither party, yet it proves good and beneficial to them. Therefore, this I say to you, when you judge of patents, hear the patentees' counsel patiently; say not presently it is against law, for patents are not to be judged unlawful by you. I must first believe myself and my counsel, and then you are to give your opinion of the conveniences that ensue thereupon."

Sir Edward Coke stated, that a great contempt was offered to the House by one John Pecke, who had refused when ordered to bring in his patent—the sergeant was ordered to fetch him.

The king, by proclamation, offered those who might find gold and silver mines in the county of Gardigan, a lease of twenty-one years of the mines which they discovered, and a tenth part of their produce at the end of two years.

One William Jones, a merchant living in Austin Friars, says Fuller, "fetched from Norimberge the first form of the engine which is used to quench scare fires in London; and obtained a patent from the king, James, that none should be made without his consent." Two were begun, but not finished, in his lifetime; he died of the plague a few years after this.

Sir Edward Coke was one of the number who conducted the various conferences between the Houses upon the amendments of the Bill of Monopolies, in progress through the House of Lords. The Commons were most urgent to speed the measure, and on two occasions, when Coke carried up some other bills to the Lords, he solicited them to "remember the Bill of Monopolies," and the Chancellor as often replied that "the bill would be expedited;" after various conferences, it passed both Houses and received the royal assent.

The preamble of this Act was formed by a recital of the proclamation issued by the king in 1610; and by this dexterous reference to that document his majesty was made not only to condemn himself and the numerous obnoxious measures he had sanctioned since it had been published, but to put it on record as the most ample possible justification of all the numerous unconstitutional and often tyrannical proceedings of the majority in parliament in opposing the royal prerogative and the law of the land.

By this comprehensive statute, monopolies therein defined were declared to be contrary to the laws of the realm, and "were to be tried and determined according to the common law, and not otherwise." All persons were disabled from exercising a monopoly, with the exception of Sir Robert Mansel for making glass with sea-coal, Lord Dudley for smelting iron, Abraham Baker for the manufacture of smalt, and James Maxwell for exporting skins. Future grants, for the manufacture of saltpetre, the casting and making of ordnance and shot, for the manufacture of alum, and for printing, were also saved from the penalties imposed by the act.

But "letters patent and grants of privilege for the term of 21 years or under, heretofore made, of the sole working or making of any manner of *new manufacture*, may be made to the *first and true inventors of such manufactures*, which others at the time of making such letters patent and grants did not use, so they be *not contrary to the law* nor *mischievous to the state*, by raising the price of commodities at home, or hurt of trade, or generally inconvenient, the same should be of such force as they were or should be if this act had not been made." And if the same grant was made for more than 21 years, then it was to endure for the term of one and twenty years only from the day on which it was issued.

"Letters patent and grants of privilege for the term of fourteen years or under, *hereafter* to be made, of the *sole working or making* of *any manner of new manufactures* within this realm, to the *true and first inventor* and *inventors of such manufactures*, which others, at the time of making such letters patent and grants, shall not use, *so as* also *they be not contrary to the law, nor mischievous to the state*, by raising prices of commodities at home, or hurt of trade, *or generally inconvenient*, the said fourteen years to be accounted from the date of the first letters patent or grant of such privilege hereafter to be made, but that the same shall be of such force as they should be, and none other, if this act had never been made, and of none other."

This statute, which is merely *declaratory* of the common law, defines, for the first time, the limit beyond which a certain description of royal grant may not extend in future. It contains no clause by which the subject can *claim* the grant as a *right*. At the humble petition of the author of a *new invention*, "the sovereign, as the patron of arts and sciences," may extend the royal notice to the petitioner, and make a "free gift" to him of the *benefit of his own thought or invention* for a short period of years and no longer; always with one certain condition—that the inventor shall pay a large sum of money (in the majority of cases infinitely beyond what the free gift is worth) in the shape of fees and dues, and accede besides to any other condition that the "sovereign, the patron of the arts and sciences," may impose, in the shape of a share or a reserved rent in the profit of the invention; for the Act contains no clause restraining or limiting in any way regal rapacity or extortion. King Charles, we shall see, did not feel himself much bound by its enactments when he wanted money, and his Parliaments were equally unscrupulous when it suited their rebellious purposes.

1625. The manufacture of alum has at length made great progress. The king says "that greate and commendable worke of makinge of allome of the native mines of this our kingdom, not manie yeares since discovered within our county of Yoarke, is by the disbursements and expenses of sondrie greate sommes of monie by our moste deare and royall father, king James of blessed memorie, brought to perfection; as there is now no doubt or question but sufficient quantities of good, well roached, and merchauntable allome may be made as well for supplye of our owne domynions of soe necessarie and useful a commoditie, as alsoe for foreygne vent and sale of great quantitie thereof unto other neighbour kingdoms; which being a worke of greate honor to this kingdome, and of such use and consequence for the publique goode and service of this commonwealth, whereby many familyes of our lovinge subjects are kept and maintayned in worke, much treasure saved within the lande which was heretofore exported for furnishynge of allome from forrayne partes, and some encrease alsoe brought to our annual revenues towards the said excessive charge and expense which our said deere father was put to about it; we have therefore thought fit to commaunde that no forayne allome be hereafter ymported, nor any English allome that has byn exported shall be againe ymported."

Sir Hugh Middleton having succeeded in working and digging mines and mineral workes of goulde, silver, copper and lead holdinge silver in the county of Cardigan, farmed the mines for 31 years, and had power to cut, dig, and carry away stones, tyles, clay, turf, peat, heath, and other materials, for his use, upon "any commons, waistes or mountaines of Cardigan." For a time this was a most profitable adventure. Large sums of money were cleared under the grant, which, however, were subsequently lost by Sir Hugh in another speculation.

The patent to coin farthing tokens was now in the possession of the Duchess of Richmond and Sir Francis Crane.

Patent to WILLIAM BEALE, of London, goldsmith, who having "by his owne studie and industrie, and with great charge and long practice, brought to perfection a newe invention, how, by the use and applyinge of certen compounded stuffes and waters, called by the name of cement or dressing for shippes, as well as the bulkes, hulles, and bodies of shippes and other vessells, as their mastes, deckes, tackle, sayles, and other fernitures, may be preserved at fight in sea from burnyne or consumynge by wildfyre or gunpowder, and also how by the like meanes such shippes and vessells as are bound for long voyages may, without sheathing or other like charge, be preserved from hurt by the sea-worm or barnacle, whereby many shippes of great value are oftentimes utterly spoyled. We being graciously well pleased to cherish and encourage all such ingenious and profitable inventions as tend to the publique use, saftie, welfare, and service of our loving subjects in their forrayne trades and adventures by sea, and finding it agreeable to our honour and justice that the authors and first inventors thereof should in some measure reap the fruites of their labours, studies, and industries, for encouragement of them and others in the like good and laudable endeavours," letters patent were granted to William Beale for 14 years,—rent 40 shillings yearly. These waters were to be compounded from English materials and minerals, and power was granted to Beale to dig for them in all commons, waistes, and like grounds, and prevent other persons doing so without his leave.

Patent to Edward Knapp, for sole making of his new devised axletrees of metal for coaches, carts, waggons, or carriages, for 14 years; rent, 40 shillings a year to the king.

Patent to THIRTEEN PERSONS, "freely to use and exercise the art and faculty of playing comedies, tragedies, histories, interludes, moralls, pastorals, stage playes, and such other like as they have already studied or hereafter shall use or study, as well for the recreation of our loving subjects, as for our sollace and pleasure when we shall think good to see them during our pleasure."

"For the mayntenance and increase of the mynes of salt peter. The king taking into his consideration the most necessary and ymportant use of gunpowder, as well for supply of his owne royall navie and the shippinge of his loving subjects, as otherwise for the strength, safety, and defence of his people and kingdomes, and how greate a blessinge it is of Almightie God to this Realme that itt naturally yeildeth sufficient mynes of salt peter for making of gunpowder for defence of ittself, without anie necessitie to depend uppon the dangerous chargeable and casuall supply thereof from forraigne parts, hath sett downe certen orders and constitutions to be from henceforth inviolably kept and observed, for the better maynteyning of the breede and increase of salt peter, and the true making of gunpowder.

"Noe person doe from henceforth pave with stoane, or bricke, or floure with boarde, anie dovehouse or dovecote, or laie the same with lyme, sand, gravel, or other thinge whereby the grouthe and increase of the myne of saltpeter maie be hindered or ympaired, but shall suffer the floure or grounde thereof to lye open with goode and mellowe earth, apt to breede increase of the myne and saltpeter, and so contynue and keep the same. That no innkeepers or others that keepe stables for travellers and passengers doe use anie deceiptful meanes or devices whereby to destroy or hinder the grouth of saltpeter in those stables. And that no stables att all be pitched, paved, or gravelled where the horse feete used to stand, but planked only; nor be paved, pitched, or gravelled before the plankes next the mangers, but that both places be kept and maynteyned with good and mellowe earth, fitt and apt to breede and increase the myne of saltpeter and laide with nothinge which may hurte the same.

"That all and every such person and persons as having had heretofore had anie dovehouse, dovecoate, or stable (which were then good nurseries for the myne of saltpeter) have sithence carried out the good moulde from thence, and filled the place agayne with lyme, gravel, sand, rubbish, or other like stuffe, or paved or floored the same, whereby the grouth of saltpeter myne there hath byn decayed and destroyed, shall and doe within three moneths next contryve to take up the pavements and boardes againe, and carrie out the said gravell, lyme, and offensive stuffe from thence, and fill the place againe with goode and mellow earth, fitt for the encrease of saltpeter, three foote deepe at the least, and soe contynue and keepe the same for the breede of saltpeter myne. No person of any degree whatsoever was to denie or hinder the saltpeter man workinge any earth; nor was any constable to neglect or forbear to furnish him with convenient carriages necessarie for his worke; and every justice to whom the saltpeter man should address himself for assistance, was at his peril to fail to render it, that his majesties service might not suffer by his default. And no one was to give any gratuity or bribe to the saltpeterman for forbearinge or sparinge of anie grounde or place which may be digged or wrought for saltpetre." Every one was prohibited from making gunpowder, except with such saltpeter as was made by warrant from the king's commissioner; those who made it were to sell it only to the king's powder maker, at the royal storehouse. And the powder maker was not to charge more than 10 pence a pound for the gunpowder—all of which was to be proved by the proof master, and then marked.

To lessen the annoyance to the owners of these dovecotes and stable beds of saltpetre, and to promote the comfort of the pigeons, the saltpetre man was "to dig and carrie away the earth in such convenient time of the daie, and work it in suche manner as maie give least disturbance and hurte to the pigeons and encrease of their breede, and in the chiefe time of breedinge that it be not done above two howers in anie one daie, and that about the middest of the daie when the pigeons use to be abroade. And shall in like seasonable tyme carry in the saide earthe after it shall be wrought, and spreade itt there and make flatt the floure of the dovehouse, and leave it well and orderlie."

In another proclamation issued two years after this, it was ordered that "whensoever any ould building or house in London, within 3 miles, is to be pulled down and removed, notice is to be given at the king's storehouse in Southwark, that the deputy may first take as much of the earth or rubbish as in his judgement and experience is fittest for saltpeter for the king's service."

The book manufacturers, particularly those of Oxford and Cambridge, were suffering from oversea rivalry, and the king directed "for preventinge the common errors of the presse which have heretofore happened in printinge the bookes and workes written in lattyne for the publique advauncement of religion and learninge in our Universities of Oxford and Cambridge, but divers bookes of that kynde after they have been well and carefullie first printed here, in goode paper and with goode letters, have byn afterwards in the partes beyond seas reprinted very erroneous, and sent back from thence into this kingdome and vented here as true coppyes, at lower rates in respecte of the basenes of the paper and printe than the originals here can be afforded, whereby the authors have byn obliged to desclaim their owne workes soe reprinted, the first printers much impoverished, and our owne people much abused in laying out their moneys uppon falsified or erroneous coppyes, that no lattyne author's booke which have byn or shall be formerly and originally printed at Oxford or Cambridge, shall be imported if printed beyond seas."

Patent to SIR JOHN BROOKE and THOMAS RUSSELL, Esq., to make saltpetre by a new method. Under this grant the patentees erected works on a large scale in Southwark.

1626. The committee of grievances, which had annoyed King James during his whole reign, was again formed in the first parliament held by King Charles, and proceeded in the steps of its predecessor. In its list of grievances presented to the king were enumerated the patents for fishing in America, for briefs, for survey of seacoal, and "for the lighthouse at Wintertoness, in which the king had given no satisfaction," Gregg's patent for examination of witnesses, and one for purveyance, and some others. It expressed a desire, of which no notice was taken, that the king would license the export of 50,000 *white* cloths, instead of 30,000, in order to make a vent. For centuries it had been the endeavour of the country patriots to hinder what they now prayed for.

Parliament being informed that a grant had been made to J. Burlamachi and Jacobson to export some ordnance, sent a message to the king to stay it. Charles said none had been shipped hence for six months, and none should be while the regulation of the trade was in discussion.

Leather had become scarce and high priced. The French tanners and curriers had improved the quality of their staple, and great quantities of hides and skins were exported for their use from England. They were sent to Hull, thence to Scotland, from which they were conveyed to France, "under collour of calf-skins, though great numbers of a smaller growth (than the legal standard) were transported." Exportation to Scotland was forbidden, as well as to foreign places.

The manufacture of saltpetre, says the king, had hitherto produced much trouble and grievance to the lieges, "by occasioning the digging up the floors of their dove-cotes, dwelling-houses, and out-houses; and had also occasioned great charge to the saltpetre men for removing their liquors, tubbes, and other instruments, and carrying them from place to place;" but now divers compounds of saltpeter can be extracted by other methods, for which SIR JOHN BROOKE and THOMAS RUSSEL, Esq., have received letters patent.

To encourage so laudable a project, "all our loving subjects," continues his majesty, "inhabiting within every city, town, or village, after notice given to them respectively, shall carefully and constantly keep and preserve in some convenient vessels or receptacles fit for that purpose, all the urine of man during the whole year, and all the stale of beasts which they can save and gather together whilst their beasts are in their stables and stalls, and that they be careful to use the best means of gathering together and preserving the urine and stale, without any mixture of water or other thing put therein. Which our commandment and royal pleasure, being so easy to be observed, and so necessary for the public service of us and our people, that if any person be remis thereof we shall esteem all such persons contemptuous and ill affected both to our person and state, and are resolved to proceed to the punishment of that offender with that severity we may."

Sir John agreed to remove the liquid accumulations from the houses once in every 24 hours in summer time, and every 48 hours in winter time.

The patent granted to MR. MORE and others, for the making of salt, was brought before the committee of grievances, who found, said Mr. Whitby, that no valuable consideration had been given for it, nor any rent reserved, nor does it describe the manner of the new invention, though it contains a non obstante. It is no new manufacture, for salt was made in this way before; and the addition of a circumstance does not make it a new invention. The patentees are not the inventors, but one Waymouth, and the invention in this case is not assignable. Besides, the grant contains divers inconvenient clauses, and exorbitant powers to make laws for making of salt in England and Ireland.

Mr. More protested if his patent were condemned by the House he would extinguish it.

A few days afterwards he was heard in his own defence for the patent; when he withdrew, the question was then put, and his privilege was unanimously voted a grievance. He, as the patentee, was then called in, and taking his place, and standing up uncovered, was admonished by the Speaker, and then "he gave his own voice for damning the patent."

On a subsequent day More, on his own part, and others on the part of the Earl of Warwick, Mr. Parker, and Mr. Trombold, his partners, stated they were willing the patent should be annihilated; and More and his friends then pledged themselves in the beginning of term to enter a disclaimer upon the quo warranto depending in the King's Bench.

Next day More was called to account for some disrespectful and contemptuous expressions he had applied to the parliament, and it was voted to send him to the Tower. He was brought in and received his sentence kneeling, but being excused from any ill intention the punishment was not inflicted.

Patent to EDMUND FELTON and JOHN DREWE for sole making of engines for draining water out of all mines, as well of tynne, lead, copper, as all other mines, and to convey water from place to place to dry and barren grounds,—for 14 years.

Patent to SIR JOHN HACKETT and OCTAVIUS DE STRADA, to make sea coal and pit coal as useful as charcoal for burning in houses and chambers, without offence given by the smell or smoke,—for 14 years.

At this period there was a great and general prejudice against sea coal as a domestic fuel. This clever attempt to substitute coke for wood and charcoal, however, failed, more from want of a proper grate to consume it in, than from dislike to the improved combustible.

Patent to THOMAS ROUS, alias RIUS, and ABRAHAM CULLYN, sole working and making of stone pots, stone jugs and stone bottles, according to their new invention, —for 14 years.

Patent to RICHARD LORD DACRE, THOMAS LETSOME, and NICHOLAS PAGE, "the sole making of steele according as it is now invented by Thomas Letsome," —for 14 years.

Patent to GEORGE SANDS, to print "XV Bookes of Ovids Metamorphosis in English,"—for 21 yeares.

Patent to JOSEPH WEBB, Doctor of Physic, for the sole teaching, by himself or substitutes, the writing and speaking the tongues by the way and method by him invented, and for selling and printing such books as shall be of his invention, or by him made serviceable and conducing to that end. The patent describes the doctor's method to be "a more exact and sufficient waie of teaching to write and speak the tongues than hath hitherto been communicated to the publique benefit; and it is so short, playne, constant and easie as shall comply with the meanest capacities, and work in quicker apprehensions effects of admiration, whereby they may without any toil, losse of time, or waste of charges, as heretofore have been accustomed, come to a pure, eloquent, judicious and unerring form of writing and speaking the tongues, and so proceed to those higher studies and employments whereunto languages serve but as the hopeful instruments." Term of patent, 14 years for teaching and 31 years for selling his books; for the first three years without any payment, after that "one-fifte part of the cleare benefit by the sale;" and if this rent remained in arrear, £10 a week was to be paid to the king as a penalty,—a hard bargain this to be driven by a royal patron of learning.

Webbe published in 1622 an "Appeal to Truth, in the controversy about the most expedient course in Languages,—to be *read fasting*."

Patent to Arnold Rotsipen, for "a new arte, industry, way or meanes, not formerly performed or practised, of which he hath showed a patterne and proofe to ourselfe,—to make all sortes of gonnes, both great and small,"—for 14 years; and others were prohibited from setting up or useing any furnace or house, mill hammers or engines, like those of the patentee.

When the monopoly of the gold wire drawers was before the parliament they stated that they were free of the Goldsmiths' Company, and were an ancient trade in the time of Edward IV., and that the manufacture was profitable to the king; that they had imported upwards of £40,000 worth of bullion; that melting the coin, which they were alleged to have done, would have been a great loss instead of a gain to them; that the gold wire drawers were only nine in number, but the various branches of the trade employed upwards of 2,000 people; that the public spent £8,000 a month for gold thread, the metal of which when used was not depreciated more than a third; that "other nations, such as France and Denmark, tried to have this trade, and sithence men and women will be brave, no bravery could be had with less cost."

The silkmen and their workfolks, estimated at 10,000 families in and about London, advocated the importation of Venice gold lace. This they showed was returned for English coarse cloth vented in Italy, and which therefore vented our own cloth here, and the silk they used was also had in exchange for cloth. The export of cloth for silk alone far exceeded what could be had for the home-made gold thread.

The gold thread and wire drawers succeeded, however, in having a twelvemonth's longer respite, and liberty was given "to strangers born out of the king's dominions to wear excessive apparel and gold lace," that the native workmen might not be without employment.

1627. Patent to "William Parham, Ambrose Prewett, and Charles Jacob, for an engine that shall enforce all manner of mills of what nature or kind soever, to grind and perform their wonted labour without help of either horse, wind, or water," —for 14 years, under a yearly rent of 100 pounds.

"NICODEMIO MATTAXA took the art of printing, which he had learned in England, to Constantinople."

Patent to WILLIAM ASTELL, JOHN COPLEY, and FRANCIS CROFTS, to put in practice the art and way for milling of iron ore, and for making the same into cast work and bars, with sea coal and pit coal,—for the term of 14 years.

WILLIAM BROUNKER and others, to exercise and put in use an instrument or device for earing and plowing of land without either horses or oxen,—for the term of 14 years.

Patent to WILLIAM DRUMMOND, of Hawthorndean, near Edinburgh, for the fabrication of warlike machines. The first is an equestrian instrument, by which a single horseman may be equal in fight to five or six armed with their common arms, which instrument indeed agrees most excellently with the foot service, and from effects not less terrible than speedy, is called the *thundering staff;* but from its various properties the box pistol, box musquet, box carabyn, or *box dragoon.*

The second is a new kind of spear, with which any foot soldier, besides using it as a pike, may discharge five or six guns. This weapon may be named the *projecting spear,* or arquebus.

The third is a sort of machine of congregated musquets, by the assistance of which one soldier or two are enabled to oppose a hundred guns, which machine, from its effect, is called the *thundering chariot,* and vulgarly the *fiery waggon.*

The fourth is a new species of gun of the greater kind, by the assistance of which, in the same time that they have been able to discharge one ball, they may now discharge three, four, or five, and that either in a land or sea engagement. Of this machine there are different figures and sizes, but from the common property of all they may be called, from the general name of the open cannon, vulgarly the *open ordnance.*

The fifth and sixth are of the mortar kind, of which one, from its remarkable use in defending walls and ships, and from its wonderful expedition, is called the *flat scourer;* the other, which is extremely useful in naval fights, for breaking the masts, yards and oars, whence it is called the *cutter.*

The seventh is a machine not unlike a species of the ancient heliopoles, accommodated to the modern discipline for defending a fortress, and also for attacking one; by the assistance of it the besiegers may enter into the inner part of a city or fortification or over a ditch, without the use of rolling mounts; and in the defence of a city, the fortification may be so strengthened by the use of this machine, as it shall never be taken nor demolished, and it will stand free on the curtain. This, from its likeness to a cavalier, and because it carries a number of soldiers and has the power of motion, may be vulgarly called the *elephant*, or *cavalier errant.* The *leviathan*, the *wind measurer*, the *sea postillion*, the *length compass*, the *ship fountain*, the *lynx eyes*, and the *mover*, were improvements in shipping, but all more or less adapted to warlike uses.

1627. No snaffles to be used for horses, but bits, "as the horses are more apt and fitt to be managed by such as shall ride them being used to the bit than the snaffle."

The exact time when long bows were disused is unknown; but in 1621 it was moved in parliament to repeal some regulations, as "guns be now the service of the state and long bows obsolete." Arrows were shot by the English at the Isle of Rhé in this year.

Thirteen years after this time the "Earl of Essex tried to stir up the well affected, and to raise a company of *archers* for the king and parliament."

The king, in his special commission for surveying arms and armour in the country, which he gives to the company of armourers and pike makers, because they are the skilfullest gun-makers and pike-makers in the kingdom, mentions "divers cutlers, smyths, tynkers, and other botchers of arms, spoiling much." No arms were to be sold without the armourer's stamp of proof.

Kilmarnock and Dune are now famed for the fabrication of weapons, and they kept their reputation until the middle of the 18th century.

Snaphaunce was a fire arm which had a moveable hammer placed beyond the pan, in imitation of the cock to a wheel-lock, and brought down upon it in the same manner. The cock being placed according to the present mode, strikes against it on pulling the trigger. The hammer is furrowed in imitation of the wheel in a wheel-lock. To make the fire-lock, which was a somewhat later invention, this hammer was affixed to the pan, supplying the place of its cover, and as is well known opening on the percussion. These hammers retained their furrows to the middle of the eighteenth century. English matchlock guns were made for ten years after this period, until about 1640.

1628. Patent to HUGH BULLOCK, for sole making of an engine for the easy cutting of all sorts of timber into planks and boards—for 14 years, at a rent of 40 shillings.

Patent to NICHOLAS BRYOTT, to be a free denizen, with power and authority to frame and engrave the first designs and effigies of the king's image, in all such sizes and forms as are to serve in all sortes of coins of gold and silver.

Patent to HENRY JERMYN and others, to put in use a medicine invented by Sir Roger le Gris, for the preservation of sheep from the rot,—for 14 years, under the yearly rent of £100.

Patent to HUGH WYATT, sole making of engines and instruments for the safe transportation of horses and other cattle out of Ireland into England,—for 14 years.

Patent to ANDREW BURREL, to erect such engines, devices, and instruments, as he shall think fit for the draining and making dry of fenn and marsh grounds.

Notwithstanding the stringent clauses in the Act of Monopolies, many illegal grants had since been issued, and were in operation. Among these, the Committee of Grievances named the patent to LEVATT, for bridges; the patent to TRUMBUL, a foreigner, to exchange money; the patent to LORD STANHOPE (for 80 years), to carry out letters from the kingdom; the patent to the GREENLAND COMPANY. All patents were to be brought to the House for examination.

One PECKE, who had been ordered to attend with his patent for hawks in the last parliament, having disregarded the mandate, and eluded the sergeant-at-arms, was again ordered to produce his grant to the House, and the sergeant-at-arms desired to "bring Pecke to answer for his contempt."

During this discussion, the indefatigable and upright Sir Edward Coke was, on account of his great age, excused by the House from being chairman of the Grand Committee of Grievances, that had under his leadership *frightened* so many patentees and demolished so many patents.

1629. In consequence of complaints, says the king, often made to his father, James I., of the great inconveniences produced by the conversion of large quantities of wheat flour, meal, and other things fit for the food of man into starch, and the unsavoury smells and noisome stenches created in making it, James I. had often tried to amend these evils, but his care was as often frustrated by the wilfulness of the starch-makers. He then endeavoured to abate the nuisances, by forming the starch-makers into a corporation, binding them not to make starch of wheat flour, meal, or other prohibited thing, but of pollard or bran only; nor maintain any starch-house which would be an annoyance to others; but nevertheless many tradesmen, out of a greedy desire of gain, have left their owne occupations, and taken upon them to be starch-makers, and evade the regulations; and as the price of corn is now high, a surveyor is appointed by the king to see that the conditions on which the grant was made are fulfilled. No starch is to be sold except that made by the corporation; nor is starch to be vended by any person or hawker who sells it from door to door, but only by traders in their own shops and warehouses.

The erroneous anxiety of the country, which had been so often expressed in parliament, to hinder the exportation of ordnance, was now openly set at nought by the king, who granted a special commission to Philip Burlamachi, to sell 4,000 tons of iron ordnance, to be delivered in two years, for certain sums of money, " in order to get out of pawn divers parcels," says the king " of our plate and jewels of the late George, Duke of Buckingham, pawned to several persons at Amsterdam for sums not yet paid, according to a true statement testified under the hand of Sir Sackvile Crowe." The quantity to be exported, and the comparatively short time within which it is to be delivered, both indicate an increasing energy in the iron trade.

It has been observed, at the commencement of the reign of King James, that the London merchants hired foreign ships in preference to building vessels for themselves. This state of things is now reversed, foreigners are becoming purchasers of English ships. And to check the trade, the king, in deference to the public wish, orders " that no one was to sell or alien, by any ways or means, any ship or other vessel of what burden soever made or built within his dominions, which is fit or may be made fit to sail on the sea, to any manner of person, either born or resident out of his dominions."

The company of Eastland merchants, who had the sole exportation of English commodities to the north and east of Europe, and importation of the produce of these parts, was a monopoly well esteemed by the country, although most injurious to the public interests. They monopolized the importation of " hemp, yarne, cable yarne, flax, potashes, Polonia wool, cordage, eastland linen cloth, pitch, tar, and wood. Whereby," says, but most erroneously, the king's proclamation in their favour, that " the kingdom hath been enriched, our ships and mariners set at work, and the honor and fame of our nation spread and enlarged in these places."

In the previous reign, the bad state of the roads had drawn attention to the injury done them by the large size of the carriers' carts. The former regulations were enforced, and no carrier was to travel with more than 20 hundredweight in one cart, nor draw with more than five horses.

1630. The inferiority of English dyed silks to those of continental manufacture was considered to be owing to the English dyers using certain prohibited dye-woods and gums. The regulations made to remove this say—No dyer was to use any slip, alder bark, fylings of iron, or other corrupt or deceitful matter, in dyeing silke either into blacke or into collours, whereby the weighte of the silke shall be encreased.

No silk was to be dyed of any other black colour than "Spanish blacke." That known as "London blacke or light weight" was forbidden. The gum was to be fairly boiled out of the raw silk before dyeing, so that silk weighing 16 ounces before boiling should weigh 12 ounces only after it was dyed. Silk weighing a pound before being dyed "Spanish black" shall weigh no more than 16 ounces when dyed. No pound weight of silk dyed into these sad colours, liver colour, deroy, tawney purple, french green, gingerlyne, deere colour, orange colour, or light russet, is to exceed 13 ounces when dyed.

Sixteen ounces of silke, dyed into what are called light colours, shall not exceed 12 ounces when dyed—nor if into grain colours shall it exceed 13 ounces. Silk used as white or light yellow for silver and gold shall weigh not more than 12 ounces, and the throwster was prohibited from using any gum or syrup to increase the weight, and no one was permitted to dye the silk he made.

The exportation of woolles, says the king's proclamation, of woollen fells, woollen yarne, fuller's earth, and wood ashes, great meanes to the making of cloth, was a principal impediment to the vent of our cloths in England, and the false and deceiptful dying and dressing here of our cloths and stuffs made of woolles, did exceedingly disgrace and discredit the drapery of this kingdom, and very much hinder the vent of its commodities; it was therefore again ordered, that in dying stuffs no one was to use logwood or blockwood, which had been already condemned by several laws and proclamations. Wool yarn and fuller's earth and ashes were not to be exported. "And for the better utterance of cloth within the kingdom, if any *blacks* be hereafter given at burials, such only shall be of cloth and stuffs of English wool."

Patent to Edward Ball, Edmond Lassells, Robert Hampton, and William Audley; who have found out means so to prepare and order the fuel of peat or turfe by reducing it into a coal, that it shall serve for the making, melting, forging and fining of iron, lead and tin; boiling salt; burning of brick, tile, and lime; or any other thing whatsoever for building, without the addition or use of any wood, charcoale, pit coale, or sea cole, an invention never brought heretofore to perfection in England, and sparing and preserving wood and coal, and improving ground whence the peat comes off, and employing numbers of poor and distressed people, —14 years, at a rent to the king of £6 13*s.* 4*d.* yearly.

Patent to Clement Cotton, to print for 21 years a Brief Concordance to the last translation of the Holy Bible.

"Iron wyer is a manufacture that has been long practised in this kingdom, and by that trade and mistery many thousands have been for a long time well and honestly employed, but who are now destitute. English wyer is made of the toughest and best Osmond iron, which is a native commodity of this kingdom, and is better for making cards for wool than that which cometh from abroad. Nevertheless, great quantities of iron wyer are imported, and the makers of wool cards are much deceived by foreign wire, which henceforth, together with hooks and eyes, and other manufactures made of foreign iron wire, are prohibited being imported."

The first lottery drawn that is mentioned in the statutes.

Patent to David Ramseye, Esq. and partners:—

"Great prejudice doth arise to us and our crowne, from the several patentees being unable to make a separation of the metals of the mines, and they daily cast away and lose much of those mynes which contain gold and silver. Ramseye hath found out a new way or invention to make separation, by taking the second scum off all such metals of tin, lead, or copper, after the dross is taken, preserving as well the impure metal as the pure; without prejudicing any of our subjects—grant for 14 years, under a reservation to the king of one-third of all benefit or profit, with a further privelege for 21 years to dig and search in the parts of Yorke and Somerset and Devon, where have been mines, to find such mineral works of gold, silver, and lead, in order to extract the gold and silver ores, and reduce the lead, reserving to the king a tenth part of the profit after the first two years."

William Smith, Thomas Lewyn, to import coach horses, coach mares, and coach geldings, from parts beyond seas, not under 14 hands high nor under 3 years, nor exceeding 7 years of age—for seven years.

Patent to "David Ramseye, Esquire, groome of ourPrivie Chamber, and Thomas Parker, Edward Bisse and Richard Jarret, who have found out and perfected an instrument, engine, or device, by way of a barrel engine, and otherwise for the raysing of water out of mines, graffs, coale pits, or any other place, how deep soever, to any high place. Know yee, that we graciously favouring and willing to cherish such ingenious and profitable inventions, and holding it fit in honour and justice, and it being agreeable to the lawes of this our realm of England, that the inventors and authors of so laudable works should, in some measure, reap the fruits of their own labour, grant liberty to make and use the said machine for 14 years;" reserved rent 26*s*. 8*d*. yearly.

A proclamation directs that "no graine mete for bread to feede man to be wasted and consumed in stuffe called starch."

Patent to Paul Willet, clerk, for profits of a book called "Synopsis Papismi," written by his father, on condition that it shall be "printed and published at a cheap rate for the benefit of those who cannot buy a dear book,"—term 21 years.

Patent. "DAVID RAMSEYE, Esquire, groome of our Privy Chamber, who hath, by his humble petition showed unto us that he hath by his great pains, industry, and charge, found out, invented, and perfected divers new ways and inventions; that is to say, to multiply and make *saltpeter* in an open field, in *fower acres* of ground, sufficient to serve *all* our dominions. To raise water from low pits by fire. To make any sort of mills to goe on standing waters by continual motion, without the help of wind, water, or horse. To make all sorts of tapestrie without any weaving loom or waie ever yet in use in this kingdom. To make boats, shipps, and barges, to goe against strong wind and tide. To make the earth more fertile than usual. To raise water from low places and mynes, and coal pits, by a new way never yet in use. To make hard iron soft, and likewise copper to be tuffe and soft, which is not in use within this kingdom; and to make yellow wax white very speedilie." Term of 14 years, on a yearly payment of 3 pounds 6 shillings and 8 pence.

The small rents which the king reserves in his grants to Ramseye, show that the patentee stood very high in the king's favour—or that he was thought an incurable dreamer.

1630. Patent to ROGER ELLIS, (JACOB WILLIAMS, Esqrs., FRANCIS TUCKER, HUGH WOOD, EDWARD GANNEL, WILLIAM MESHAM, and WILLIAM LIPTRATE,) "who hath received some notice of some hidden treasure, and being willing to become an adventurer in the trial thereof, hoping to bring into our coffers, and also to himself and his associates, a good fame and profit without prejudice to anie,—we give our letters patent for fower years, to search, dig, and delve in such places as they shall conceive hopeful within our realm of England;" giving a fourth part of their findings to the king, free of all charges.

1631. Patent to STEPHEN GIBBS, Gentleman, for certain means for defence of marsh lands against the sea and fresh water surrounding, and also thereby to recover and make useful for shipping the most of all such havens and harbours as have been and are swarved up and decayed by the sea and fresh waters, strife, and imbarrement.—Gibbs to pay 20 shillings a year.

Patent, addressed to the COMPANY OF STATIONERS, to print certain Latin books. Foreign editions prohibited from being imported.

Patent granted in 1618 to Captain JOHN GILBERT, by King James, to forme water-ploughs for the taking up of sand, gravel, shelves and bankes out of the river Thames, and other havens, harbours, rivers, waters, wherewith they are choked, or any other engine or engines which they can invent for the taking up gravel, or for the raising of water in greater quantity and to a greater height than hath been practised; which engines are to be moved or drawn either by some current or stream of water, or for want thereof by the strength of men or horses, and is very necessary for drawing and draining of coale pitts and other mynes, and for the service of cittyes and townes, were surrendered to James I. on a promise to regrant to Gilbert, under the great seal, for 21 years. The deed was prepared, but had not passed the seales at the time of the king's death. It was therefore now regranted by Charles I. to John Gilbert and James Freese, and their executors, for 21 years, at a yearly payment, 6 pounds 13 shillings and 4 pence.

A patent to Sir William Russel and others recites, that a patent was granted by King James to Roger Jones and Andrew Palmer for 21 years, "to practice and putt in use the mystery, art, way, means, and trade of making of hard soap with a material called *berilia,* and without the use of any fire in the boyling or making thereof, and also of making of soft soap without the use of fire in the boyling thereof; as also of burning and preparing of beane straw, pease straw, kelpefern, and other vegetables to be found in his majesty's dominions, into ordinary ashes or into pot ashes, and with the said materials of the ashes of beans and pease to make soape hard and softe at their will and pleasure, and in such way and form as they have invented and devised; and also of the using of the assay glasse for tryeing of their lee and making of their hard and soft soap by their new inventions in the way of making the soape by sundry motions, and not boyling of the same with the expense of much fuel, in such sort as was formerly accustomed by such as then usually made soap in and about the city of London. And as in Parliament holden at Westminster in the 21 James I., an act made against monopolyes was not to extend to grants of 21 years or under for sole working of any new manufacture, therefore Sir William Russel, Bart., Sir Basil Brooke, Sir Richard Weston, Sir Edward Stradley, and eight others petitioned, that as the said Palmer and Jones had communicated to Thomas Russel their invention, and as the petitioners, his assignees, had been at great charges to bring the invention to perfection, and discovered divers vegetables to be burned to make ashes, and erected divers works in different parts, not only to supply the kingdom, but to export the soape; as the king held it to be justice to encourage such as thus employed their travels, industries, and purses, and as the soape made by them was more sweete and useful than other soape, he granted them for 14 years the privilege they petitioned for, on condition that no soape was to be sold at a higher price than other soape had been sold at for the space of seven years last past."

The clockmakers incorporated, and their charter prohibits clocks, watches, and alarms from being imported. These machines, therefore, were now in more general use, and the native workmen had become expert in their manufacture.

1632. Patent to Sir Thomas Aylesbury, to make and vend all contrapoizes or weights, grains and half grains, and all balances for coins and moneys,—term, during his natural life, on paying 20 shillings a year to the king.

Patent to Richard Norwood, for special meanes to dive into the sea and other deep waters, there to discover, and thence by an engine to raise or bring up such goods as are lost or caste away by the shipwreck; for 14 years.

Patent to Thomas Farnaby, to print certain classic authors with his notes; for 21 years.

Thomas Grent, doctor in phisick, "way of making or framing several instruments.

1. An instrument very profitable when common windes doe fail, for a more speedie passage of calmed shipps or other vessels upon the sea or great rivers, which may be called the *wind's mate.*

The second, the *fishe call*, or a looking-glass for fishes in the sea, very useful for fishermen to call all kind of fishes to their netts, sears, or hooks, as several calls are needful for fowlers to call several kinds of fowles or birds to their netts or squares.

The third, a *water bowe*, being a manual instrument, made very serviceable for divers uses, especially for the more speedy preservation of houses upon the land and shipps upon the sea from sudden fire.

The fourth, a building mould or *stone press*, very requisite for the building of churches or great houses, by which stone windows, door cases, chimney pieces, are made more speedilie without hewing, cutting, sawing, carving, or engraving, as also bricks and tiles more beautiful to the eye and more durable against foul weather, being as smooth as glass on the one side or end, with divers colours and work, as if they were carved by skillful hands and curious workmanship.

The fifth, a moveable hydraulike or *chamber weather cale*, like a cabinet, which being placed in any room, or by a bedside, causeth sweete sleep to those that either by hot feavers or otherways cannot take rest, and withal altereth the dry hott ayre into a more moystening and cooling temper, either with musical sounds or without.

The sixth, a waterwork instrument, which may be called the *corrected crane*, by which wyne, oyle, or any other liquors may be transfused from one vessel which cannot well be removed to another more remote, as also water may be drawn from one place to another without any sucking or forcing by the mouth as vintners; term, 14 years, to make and put in use the said art, mystery, formes, wayes, means or instruments, or any of them, and to pay 20 shillings yearly."

For preventing frauds in drapery, it is ordered by the king, "that no wool is to be boiled with galls, unless they be first made blue with woad or Indico, according as the sadness of the cullor will bear it in blue; and no yarn to be sold in Oxon, Wilts, Glocester, except made of skeynes upon reels, so as every reel shall be of two yards or one yard. Every weaver to put his initials of name of baptism and surname to all cloth that he weaves."

Undyed cloths not to be stretched. Gig mills prohibited under a great penalty, are now used as mosing mills, wherein cloth being stretched, is wrought with teazell. All mosing mills are therefore to be taken down."

Marks of manufacturers not to be imitated, and a seale of lead is to be affixed to each piece of cloth, descriptive of its quality.

"The word *faultie* stamped upon the seale to signify that the cloth is wasted or squally, bandy, rowy, holely and the like."

"The society or company of buckle-forgers, buckle-filers, and trimmers and dressers of buckles, state to his Highness the King, that formerly buckles for girdles, hangers, bells, and other wares for men's wearing and war service, were wont to be well and truly forged and made of iron, in which trade the said company have well and honestly got their livings, and thereupon have maintained themselves and families in decent order; and that of late times there is a subtile way found out by casting of buckles in brass in deceipt of his Highnesses subjects. This matter was referred to the mayor and aldermen of London, who reported, that those buckles which are cast in brass are brittle and not serviceable as those made of iron; and that there are not above fower or six persons within London that make and cast these buckles in brasse, and that there are three hundred persons whose only means to maintain themselves and families is by forging and making iron buckles and harness, and that those who cast the brass buckles can make more in one day than ten of those that make the iron buckles can do, by reason of their slightness; and therefore, if the brass buckles be tolerated, the men that make the iron buckles must be impoverished."

His highness, to maintayne a number of poor artizans that hereby gain their livings, declares brass buckles to be prohibited, and Star Chamber proceedings shall be instituted against those who disobey the proclamation.

1633. The soap-boilers, who obtained the patent in 1631, agreed to supply good and sweet soap, and to sell it at three pence a pound, and searchers were appointed to see they made a good article. The company, however, used unsweet fish oil in contempt of their bargain, and opposed the searchers; the matter being carried into the Star Chamber, the delinquents were fined and imprisoned.

It is well known, as stated in the proclamation, that no soft soap, until lately, was made in the kingdom, except in and about London and Bristol; and in future it is only to be made in these places.

New soap, (that made by the new company,) has been found better than old soap; "16 firkins were selected for a public trial, and two laundresses were indifferently chosen to wash with both kinds. New white soap lathered much better than did the old soap called crown soap. The new white soap (that made with berilia) did not fret the skin from the washerwomen's hands, and spoil and burn their clothes. Four countesses, five viscountesses, and divers other ladies and gentlewomen of great merit, certify that new soap is the best.

"Those who objected to the soap, continues the king, had no experience, and were of mean condition; one was bedrid, the second lay in childbed, and their husbands disavowed their complaints. Only one Mrs. Sweeting affirmed that she found the new soap did wash fine clothes reasonably well, but coarse clothes not so well." To the silk dyers, who complained of the company's soap, it was promised in the king's presence that they should be supplied in future with a better article. No soap was to be sold until assayed, and all works at which unsweet soap was made were to be destroyed.

1634. Patent to WILLIAM NEAD, "a skilful archer, for a new and warlike invention for the use of the bow with the pike, in which he has spent many years in practising the same; and also for making the engines for affixing the bow and pike, and for making of a new quiver for the arrows, which he hath made it a perfect and useful service for the wars, and begun to teach the same to the Artillery Company of London, who have presented it before us and our council of state and councel of war." Term, 14 years to him and to his son, William Nead.

Patent to Captain THORNEFF FRANCKE, for erecting and making boiler furnaces, and saving fuel, and its annoyances. The brewers affirmed that it saved fuel, and the smoke from their funnels was not half of that from the old furnaces. "In iron furnaces it saved three parts out of four, and by its use they drew five times instead of three times a week." The king was so pleased with the success of this contrivance that he issued a proclamation to recommend its general adoption.

Patent to JEROME LANYER, to practise the art and mystery of affixing wool, silk, and other materials of divers colours upon linen cloth, silk, cotten, leather, and other substances, with oil, size, and other cements, to make them useful for hangings, and other occasions, which he named *Londindriana*.

Lanyer is acknowledged to be the inventor of velvet wall hangings, made by covering a surface with size or glue, and causing finely pounded coloured silk or woollen dust to adhere to it, and produce a velvetty or a cloth-like surface. It has been thought most probable that he extended his art to make what are now called paper-hangings, or paper painted or stencilled with opake mineral colours, and which, moreover, could be considered but a small step in advance of the *painted cloths*, which had been fabricated by English workmen, both in distemper or size colour and in oil, for some centuries before this period. A French writer, however, claims the invention for one Francois, who made paper hangings at Rouen in 1620, "and he supports his assertion by the patterns and wooden blocks, (preserved at the time he was writing,) with the dates of 1620 and 1630 inscribed on them. He is of opinion that some Frenchmen, who fled to England when persecuted for their religion, carried this art along with them; the inventor's son, who followed this business to a great extent for more than 50 years at Rouen, died in 1748. Some of his workmen went privately to the Netherlands, where they sold their art; and the French with great confidence maintain that foreigners in this branch of manufacture are far behind them." On this it has been observed, that it is most likely Lanyer was a refugee, yet it is unlikely that Francois was the inventor. Francois' son, at his death in 1748, must have been upward of 100 years of age, if his father was 50 years of age when he was born, or 25 years of age when the blocks were cut.

Patent to WILLIAM BOLTON, grocer, for art and skill of purifying indico.

Patent to WILLIAM PARHAM and others, for a plough to be impelled by two men, and one to hold the plough, without horses, oxen, or other cattle.

Patent to JOHN BULMER, master surveyor of mines and minerals, to take up ships and goods sunken in the sea.

Patent to JOHN DAY, sworn broker, to print weekly bills of prices.

1635. Patent to FRANCIS CHAMBERLAYNE, "to make wines of dried grapes, or raisins, wholesome, good, and to keep its natural strength."

Patent to THOMAS, EARL OF BERKS, for making certain kilns, very useful for the drying of malt and hops, with fire to be made with seacole, turf, peat, or any other of the cheapest and meanest fuel; by the use of which kilns malt and hops are sweetly dried, and houses secured from casualty of fire without touch of smoke, the decay of wood prevented, and straw saved.

Patent to HANNIBAL VIVIAN, for an engine for drawing and draining water, and raising any great weight out of tin mines.

Patent to CHRISTIAN DERRICKSON, for sole making of scowring doors to be fixed on the land side of such sluices as are made in rivers and sandy grounds subject to inundation,—14 years.

Patent to DAVID RAMSEYE, Esq., several inventions for dyeing stuffs.

Patent to Alexander and Thomas Matthew, to print bills of burying and christenings.

Patent to Matthew Cox, for making wafer seals,—14 years.

Patent to F. Franke, furnaces for melting copper.

Patent to Matthew Vandyke, for instruments to take up ships from the sea.

Patent to Nicholas Estrange, for making kilnes.

Patent to James Rolfe and Robert Alexander, to make white and red lead.

Patent to John Brown, to make iron pots.

Brown formerly had the patent for casting iron ordnance and shot, and it was now confirmed to him for a longer period.

Patent to Jerome Mide and William Webb, for an engine for cutting of timber.

Patent to Sir Sanders Duncombe, for covered chairs.

Patent to David Ramseye and others, for a method of boiling vessels of liquor.

Patent to William Barton, for several engines of motion.

Patent to Sir Theodore Mayerne, for distilling strong waters.

Patent to Edward Biddle, for extracting tallow out of bones.

Patent to George Daubroke, for melting copper into ingots.

Patent to Sir Sanders Duncombe and others, for several engines for raising water out of mines.

Patent to John Byers, for making woollen cloth impenetrable to rain.

Patent to John Innys, to form an Office of Intelligence, for entering the names of all masters, mistresses, and servants, and of all goods lost and found within, and three miles round London,—term 41 years.

This is reckoned the first register office established in Europe.

1637. Decree in the Star Chamber, confining the number of master printers in England to 20, (as in the time of Queen Elizabeth,) besides his majesty's printers, and those of the Universities.

Patent to James Handbroke and others, making snuff after way used in Holland.

Patent to William Westby, for new way of making pantiles.

Patent to Philibert Vernatt and others, melting and refining iron and other metals.

Patent to Robert Lindsey, Esq., for method to avoid the annoyance of smoke in brewhouses.

Patent to the Earl of Thanet, to buy and spend so much underwood for the making of iron as will keep one furnace in work,—for 21 years.

Patent to Christopher Danbourg, sole use of divers inventions, mathematical and mechanical.

Patent to Alexander Moore, for gathering bones and rags.

Patent to Robert Lindseye, Esq., and John Hobart, making ovens.

Patent to John Shawe, for improving lands by draining.

Patent to Benjamin Stone, for making sword blades.

Patent to Sir Basil Brooke and others, for making Osmond iron.

Patent to Richard Ereemburg, for painting with oil colours on woollen cloths.

Patent to Samuel Mason, for sole making and dyeing of buckrooms.

1638. Drinking coffee may be classed among the useful arts. Evelyn mentions that one Nicholas Canopias, a Greek, who was his fellow collegian, was the first he had ever seen drink coffee, which custom came generally into use in England about thirty years after this.

Patent to Sir R. Weston, to make Castile soap. He shared in another grant.

Patent to Gaspar Whitmore, for making vitriol.

Patent to F. Ginne, to draw barges on the Thames.

Patent to John Evans, drawing water from drowned grounds.

Patent to Joseph Goodson, gilding all sorts of earthen vessels.

Patent to Oliver Lloyd and others, for new way of turning all sorts of mills.

Patent to R. Eduord, for glossing of figured and plain sattins.

1639. The act for encouraging the manufactures of linen cloth and tapestry, states that large quantities of linen cloth and tapestry are constantly imported into England, which abounds with materials for making them; it then grants to native and foreign linen and tapestry weavers the right to exercise their craft in any corporate town, and if foreigners, the weavers after three years may claim the privileges of natural-born subjects.

1640. General Leslie surprised the English army with his *tin* artillery, covered with leather. They would bear two or three discharges. One Scott, a Scotchman, who had served under Gustavus Adolphus, was their inventor.

It was moved in parliament, "that if any man here knows of any projector or monopolist that he should name him."

Some patents were sent for to be examined, and it was further "ordered that the referees of all grants of patents and monopolies, and such as have advised the king, and counselled him touching them, should be inquired of by a committee. The committee for salt, soap, wine, and leather, were to consider what profit and advantage the patentees have made out of them, and what persons have been molested, and to think of some reparation for *them*."

Mr. Harrison, a member, informed the House that he forbore to sit by reason of an ordinance of the House concerning monopolists; his humility was favourably looked on. Sir Nicholas Cripps, member for Winchelsea, being somewhat more sturdy, and standing on his right, was ordered by the House to bring in his patents for the sole trading to Guinea, for importing of red wood; that concerning the copperas stones, and also the patent for making and venting beads and beaugles. After a long discussion Sir Nicholas was expelled the House.

Four other members, Sandys, Jacob, Webb, and Windham, also accused of being patentees, were accordingly, without further ceremony, voted out of the House; and Sir Basil Brooke and Sir Tobit Matthew were sent for as delinquents, for not attending when summoned to speak to the patent for iron.

One Horth, who had detained some salt under his patent, was "commanded to deliver it up." A committee was to "consider the abuses of saltpetre men digging in men's houses, and who were the projectors and referees." Pym, in one of his speeches, said, "there was an inundation of monopolies. The soap patent *undertaken by papists* was full of mischief, enhancing the price and of bad quality."

In the same session the House itself, and Pym was present, created a monopoly. "The House doth desire and hold it fit that the heir of Sir Edward Coke do publish in print his Commentary upon Magna Charta, The Pleas of the Crown, and Jurisdiction of Courts, according to the intention of Sir Edward Coke; and that none but the heir of Sir Edward Coke, or he that shall be authorized by him, do presume to publish in print any of the aforesaid copies or books."

The matters of grievance submitted to the House were made to appear so important, and the committees for their investigation were so numerous, that a "committee for lessening committees" was found to be necessary. It reported "that the Grand Committee, and its sub-committees, should cease, in regard they have more work than can be perfected."

1641. If Heywood is to be credited, the act of King James for the limitation of monopolies and patents had not produced the expected result. According to him, "Those drones that fly about in mists, divelish projectors, damned monopolists," were as rife as ever, and he says,

> "We find them in our breade, our meat,
> In every draught or bit wee drinke or eat;
> Our bevers and the bootes wee plucke on, whether
> We have them made of calve skin or neat's leather;
> Our salt and oatmeal porridge are not free,
> But they from their ingredients must have fee.

Our cloath, stuffe, lace, points, tagges, even to a pinne,
Nay even the linen next unto our skinne,
And needle it is sow'd with: They make boote
Of every thing we wear from head to foote;
Nay, may I speak it to them, (with a pox,)
I find them even in my tobacco-box.
To leave your petty feoffors and feoffees
And come to your brave skarlet patentees,
Who when our sope of sweetest oyl was made,
By which they drove a good and wholsom trade,
These by engrost patent, coveting gaine,
Composed it all of stinking rape and traine;
For what care they, so it may make them riche,
To fill our bodye full of scabs and itch."

1643. A Fleming named Kepler, or Keffler, son-in-law of the chemist Drebbel, established the first dye-house for scarlet in England, at Bow, near London, from which circumstance the colour was called the "Bow dye." Kepler's does not appear, however, to have been a perfect process. Bauer, or Brewer, who was invited into England in 1667, by Charles II., with the promise of a large salary, first brought the art of dying this and other colours to great perfection.

The history of this dye is given on the authority of Ruhlenkamp, who was a dyer at Bremen:—"The well-known Cornelius Drebbel, a native of Alkmaar, (who died in London ten years before this date,) having placed in a window an extract of cochineal, made with boiling water, for the purpose of filling a thermometer, some aqua regia dropped into it from a phial broken by accident, which stood above it, and converted the purple dye into the most beautiful dark red; and after some conjectures and experiments he found that the tin by which the window frame was divided into squares had been dissolved by the aqua regia, and was the cause of this change. He communicated his observation to Kuffelar, (or Keffler,) an ingenious dyer at Leyden, who became afterwards his son-in-law, and who brought it to perfection, and for some time kept his process concealed, by which it got the name of Kuffelar's colour." The secret became known to one Gulich, and to Vander Vecht, one or other of whom taught it to the brothers Gobelin, in France, and the Parisian scarlet dye rose into such high repute that the populace fancied Gobelin had acquired his art from the devil.

1645. Notwithstanding the troubled times, Sir F. Crane's tapestry manufactory was still in existence. John Hulenberch and his three partners, tapestry weavers, of Mortlake, Surrey, agree to make within ten months a suit of fine tapestry, called the

"Hunters' Chace," for which Deiricke Hoste and three London merchants are to pay £540 in money and materials.

Basket-hilted swords used by Cromwell's troops generally.

1646. PETER PET, master builder, whose ancestors, for upwards of 200 years, had been master builders and principal officers of the navy board, about this time invents English frigates. The "Constant Warwick" was built this year.

Newcastle grindstones are in great request everywhere. According to Gray, in his Chorographia, "a Scot, a ratt, and a Newcastle grindstone, you may finde all the world over."

The following is "A true copy of a certificate from Emanuel College, Cambridge: Whereas CAPTAIN BULMER made several propositions which he undertook by his art to demonstrate he hath given sufficient satisfaction that he is able, i. to raise any weight from the bottom of the water to the surface without diving at all, or making use of any principle or motion, saving the form of an element only; ii. to keep any thing dry, and convey it under water, nothing thereof appearing to the eye; iii. to lift up a boat or any other weight so high as safely to deliver it on the other side of London Bridge, if need were; iv. to weigh any uncertain weight without centre, and poise it so that by adding the strength of a horse hair it may be raised up higher from its rest in the aire or water. This we could not but testifie at his request, being convinced thereof by what we have seen. Lawrence Sarson, William Dillingham, Ralph Cudworth." Bulmer had a separate proposition for blowing a boat over London Bridge, which seems to form the third project in the certificate.

"From the produce of the mines in Cardigan, Mr. Thomas Bushel, by his knowledge and ingenuity how to work them, found business enough for a mint, and with the proceeds made provision for the clothing of the king's whole army."

1649. Patent. WILLIAM PETTY, for 17 years, for an instrument for double writing, small in bulk and price, easily made, and very durable, whereby any man, even at the first sight and handling, may write two resembling copies of the same thing at once, as serviceably and as fast, allowing two lines upon each page for setting the instrument, as by the ordinary way, of what nature, or in what character soever, as in paper, parchment, a book, the said writing should be made upon. It was useful to lawyers, scriveners, merchants, scholars, registers, saving the labour of examination, discovering and preventing falsifications, and performing the whole business of writing as with ease and spirit so with privacy also. The additional fatigue to the hand above that given by a pen rendered this instrument useless, as to the chief advantage, but it seems to have been afterwards applied, with some alteration, to the business of drawing.

1650. COTTON was used in England for candlewicks and other purposes as far back as 1298, and an old poem, written about 1430, speaks of a particular sort of it. It was imported from Antwerp in 1560. The manufacture is thought to have begun a little before 1641, for in that year the town of Manchester is noticed to "buy cotton wool, that comes first from Cyprus and Smyrna, and at home works the same and perfects it into fustians, vermillions, dimities, and other such stuffs, and then returns it to London, where the same is vented and sold." The Levant and Turkey merchants are also stated to bring great quantities of cotton and cotton yarn, grogram yarn, and raw silk into England. "About 1641 the trade is considered to have been well established in Manchester, and the fustians and cottons then in use were made there and at Bolton. In 1650 the trade of Manchester was still mainly woollen frizes, fustians, sackcloths, and they bought cotton wool and yarn,—but Bolton was the staple place for cotton fabrics." No chintzes seem to have been made at this time, for the art of printing calico was most likely not introduced for some years after. Linen or flaxen yarn was used for the warp of cotton goods. *Cottons*, however, are mentioned among English manufactures from an early period. About 1538 "Bolton upon Moore, it is said, standith most by cottons, and diverse villages in the moores doe make cottons." Cottons are mentioned in an Act of Parliament in 33 Henry VIII., but all these were really *woollen* fabrics, as were also Manchester cottons, and Kendal and Welsh cottons, until about this time. When the manufacture of cotton commenced, a fabric of a *new* vegetable material then became known under the ancient name for a cloth made of animal wool; fustian also was the ancient name for a variety of coarse woollen cloth.

1651. The navigation act passed, after which no produce of any of our colonies could be brought into England, but in English or colonial ships, nor any foreign produce but in English ships, or in ships of the countries where the articles were produced or manufactured. This law is considered to mark the commencement of an era in English mercantile history.

1652. DRAINING THE FENS was at all periods partially practised in England in the marsh countries, but Morton, Bishop of Ely, is reckoned the first who attempted a systematic drainage of a district. About 1478 this enterprizing churchman began an artificial straight water-course, four feet deep and forty feet wide, from Peterborough to Guyhern and Wisbech, to carry off flood waters at all seasons; but his operations were interrupted by the civil wars. With this exception the general practice extended only to make the flooded grounds what were called *summer lands*, by forming and keeping open such private drains as would carry off the inundating waters of the summer season from particular properties only.

The statute of sewers, passed in 1537, gave no power to make new drains, or erect and maintain new banks, and was therefore of little use as a general measure to the marsh districts. The dissolution of the greater monasteries three years afterwards threw large tracts in the fens into hands who neglected the partial draining operations, hitherto mostly performed by the religious establishments. From that period fen lands began rapidly to deteriorate, and vast tracts finally became permanently submerged. The two commissions of sewers issued under Elizabeth effected no abatement of the evil.

The first statute passed for all marshes and drained land in England, in 1601, drawn up by Lord Burghley, might have been of service, but he died while it was in progress, and nothing was attempted under its authority.

Some notion of the extent of the eastern fens may be had from the description given by Camden of the drowned lands called the Great Level. He says, "They extend from the edge of Suffolke to Waynflete in Lincolnshire, which is 68 miles, and that is by the stringe; but if you reckon by the bowe of the fenne where it runneth up both sides to Witham, till you come within a mile of Lincolne, (as rotten a piece as any of the reste,) we may well call it 80 miles in length; in breadth much of it is 30 miles, more 20 miles, and seldom so little as 10 miles; a goodlie garden of a kingdome, yea a little kingdome in itselfe, as muche and as goode grounde, it is supposed, as the States of the Low Countries enjoy in the Netherlands."

From an actual survey made by William Hayward in 1605, the true content *within* the fen dykes was 307,242 acres, besides extensive districts made spungy and damp from their vicinage to the submerged portion. An inhabitant of the Great Level urging, in 1618, the necessity of improvement, thus describes it:—"Next it would be remembered that in winter, when the ice is strong enough to hinder the passage of boates, (over the drowned lands,) and yet not able to beare a man, the inhabitants upon the hards, (the spots not under water,) and the bankes within the fennes, can have no helpe of goode, no comfort for body or soule, no woman ayde in her travell, no meanes to baptise a childe, or to administer the communion, no supply of anie necessitie, saving what these desolate places can afforde. In the barons warres the rebells, upon the naturall strength of the place, resorted to it as to a fastnesse. What should I speake of the healthe of mennes bodies where there is no element of goode; the aer nebulous, grosse, and full of rotten harres; the water putrid and muddy, yea full of loathsome vermine; the earth spuing, unfast, and boggy; the fire noysome turfe and hassockes; suche are the inconveniences of the drownings."

The lordship of Thorney, containing near upon 400 acres of *dry* land, on which the Abbey formerly stood, and had 16,000 acres of drowned land around it, was let by the Earl of Bedford for £300 a year. The honour of Bolingbroke, containing

62,000 acres of drownings, was let by the crown to Sir Vincent Skinner for £18 a year, in addition to some services and dues valued at £168! Yet in the time of Edward I. "these now desolate quagmires were spots whose fruitfullness and abundance gladdened the heart of man and beast." And of Thorney Abbey in particular William of Malmsbury says that it "represented a very paradise, for that in pleasure and delight it resembleth heaven itself in the very marshes, bearing trees, that for their strength, tallness, and the same without knots, strive to touch the stars. A plain there is as even as the sea, which with green grass allureth the eye, so smooth and level that if any walk along the fields they shall find nothing to stumble at—there is not the least parcel of ground that lies void and waste there; here you shall find the earth rising somewhere for apple trees; there you shall have a field set with vines, which either creep upon the ground or mount on high upon poles to support them."

The crown possessed large estates in the fens, and James I., who took great interest in projects for draining them, offered to allow whatever part of the royal lands might be recovered to be rated or allotted in the same way as the lands of the other proprietors. He encouraged the adventurers who applied for a bill for draining the drowned lands about Ely, but the violent opposition of Sir John Peyton, the member for Cambridge, defeated the measure. The king even proposed to become the undertaker himself, and receive for his outlay 120,000 acres of the recovered ground.

Sir R. Wingfield successfully drained 6,000 acres in the county of Waldersea, and had two-thirds of the won lands as his recompense.

Sir John Popham, chief justice, and others, agreed with the king's commissioners, in 1605, to drain the whole area of the Great Level (307,240 acres) in seven years, at their own cost, and make good to the landowners all imperfectly drained portions, on condition of having 130,000 acres of the recovered lands assigned to them. King James in every way warmly promoted Sir John's adventure. Robert Hunt and Richard Atkyns, the most eminent fen engineers of the time, laid out the works; and in the morning of Wednesday, the 7th of August, 1605, this national undertaking was commenced by Mr. Hunt "casting the first spit of earth," in the presence of a concourse of fen owners and inhabitants.

The project was not only unpopular but opposed and reprobated by the poorer classes throughout the fens, who on this occasion predicted that "coming events had cast their shadows before," when Hunt was observed "to cast the first spit the *wrong way*." Want of adequate means, and gross miscalculation of the expense, an erroneous system of draining, "and the harassing opposition of perverse spirited people and libellous songs to disparage the work," retarded the adventurers' progress.

The term of seven years, given them to finish the work, was enlarged to ten years, but they finally relinquished their engagement. Another company, now called the Londoners, undertook to drain a portion, but with little better success. A tax of 20*s.* an acre was then imposed on the drowned land, to be expended for draining, but no money was paid in [a]. In 1620 the king's commissioners offered the adventurers a clear moiety of the recovered marshes, but none were found to accept it. A tax of 6*s.* an acre was imposed in 1630 on marsh grounds, but even this small sum could not be collected towards the district drainage.

In 1631 Sir Cornelius Vermuyden, who had drained Hatfield Chace, now proposed to draw, at his own expense, the surface waters from the Great Level, for the fee simple of 95,000 acres of the land which he might recover. At a meeting at King's Lynn 47 fen commissioners accepted this liberal offer; but the prejudices of the country were roused against Vermuyden, on account of his being a Dutchman. "Is the old activitie and abilities of the English nation," says one of these adversaries, "who in former times were esteemed the greatest undertakers in the western parts of the world, growne now soe dull and insufficient that wee must pray in ayde of our neighbours to improve our own demaynes. For matter of securitie shall we esteem it of small moment to put into the hands of strangers three or four such ports as Linne, Wisbeach, Spalding, and Boston, and permit the countrie within and between them to be peopled by overthwart neighbours; or if they quaile themselves, must wee give place to our most auncient and daungerous enemies, who will be readie enough to take advantage of soe manie faire inlets into the bosome of our land, lying so neare together that an army landing part in each of them may easily meet and stronglie entrench themselves with walls of water, and drowne the countrie about them at their pleasure; and this verre thing was objected by a worthy patriot in a late parliament, wherein a bill was preferred for the admitting of strangers to undertake this work, and thereupon cast out."

The Earl of Bedford, one of the commissioners, who held upwards of 24,000 acres of swamps about Thorney and in Whittlesea, was then solicited by Vermuyden's opponents to become the undertaker himself; and in January, 1630, the earl entered into a contract with the fen men to drain the level within six years, so as to make the entire area, measured by Hayward, to become *summer land*, and receive 95,000 acres of the drained grounds in full of all his expenses. Out of this he agreed to give a sop to the king of 12,000 acres. From the bargain being made at Lynn, the agreement was named *the Lynn law.*

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[a] The years 1619 and 1620 were very dry; in these seasons Borough Great Fen, of 7,000 acres, yielded such an abundance of fother that £50 a day was received for the joisting of cattle, as they called it, out of the high countries. Neither before nor after was it worth a groat an acre. "I appeal to the country," says an eye-witness, "whether throughout the fens during these seasons there were not many thousand loads of fother, where scarce anie grewe before in the memory of man. Witness the great stacks which were then seen all long the fens, as thicke to mens seeming that rode along as shocks of corne in a cornefield, and that of reasonable goode grasse;" and he asks those opposed to the improvement, if the marshes were drained would not this abundance of corne and grasse be seen in all seasons and places."

The earl divided his contract into twenty shares or lots of 4,000 acres each; he kept two shares himself. Lords Bolingbroke and Gorges had one apiece; Sir W. Russel and Sir T. Tyringham took four, and the remaining partners held each one share. They agreed to spend £500 for each lot, and pay by instalments, with a notice of ten days, or forfeit all past and future claims on their holdings and payments. This small stock, they anticipated, would almost finish their contract. Their operations were continued for several years with more or less vigour, as money was had; and a certain progress had been made, when, in order to enable the earl and his companions, who had expended upwards of £100,000, and were now as adventurers without funds and loaded with debts, to sell and mortgage their interests to raise money, the king's commissioners certified that the contractors had drained the level according to the Lynn law, and framed an order to set out and give them possession of the 95,000 acres.

Vermuyden does not appear to have hitherto been engaged in the direction of the works, though to him and his refugees the adventurers were deep in debt for work and labour. The Earl of Bedford now took him into his service, which added to the commissioners' order of setting out the metes, raised a strong opposition in the fens against the drainers. Until this period, and throughout their difficulties, the king was most friendly to the projectors. Now, however, his own embarrassments made him view fen draining as a means of income; but it was ostensibly to inquire into the complaints[a] of a crowd of petitioners against the order of the commissioners

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[a] The Earl of Lindsey drained the *Lindsey Level* in six years, at an expense of £45,000, and received 24,000 acres of the recovered lands for his outlay. All parties interested were satisfied; the land was enclosed, planted, built on, sowed, and had been reaped for two years, when the country people sent clamorous petitions to parliament; and in contempt of all authority entered on the lands, destroyed crops, drains, and buildings, and for a time held possession, and the costly embankments and sluices were nearly ruined.

At Ankholme, in 1645, some "pernicious spirits, freeholders and commoners, taking advantage of the troubled state of the country, tumultuously took forcible possession of the lands, filled up the ditches, put cattle into the adventurers' corn and pastures, cut and burned their plows, beat and wounded the ploughmen, and forcibly retarded all their operations, and prevented the payment of rates for repairing the drains, and threatened to drown the whole district." Sir J. Munson drained this tract, and had 5,827 acres of the won lands for the £16,000 it had cost him.

Other proceedings on *Hatfield Chace* were every way disgraceful. When Vermuyden began his operations, large boats laden with twenty quarters of wheat passed over 65,000 acres of land overflowed with in favour of the company, that another set of commissioners was sent by the king into the drained country, who reported as a matter of course that the earl and

fresh water, and lesser boats, looking for wild fowl and swans, navigated the area between Lammas and Michaelmas, and it kept only a small chace of red deer throughout the year. In 1642 all had been altered. On large portions of the recovered land three and a half quarters of wheat were reaped on the acre, and other parts were covered with abundant crops of rape and oats. What had not been worth six-pence an acre was now let at fourteen shillings. Instead of droves of wandering beggars and outcasts that formerly overspread the fens, they now were seen as servants hired at wages double to what had ever before been given in that district, weeding corn, burning ground, threshing, ditching, and at harvest work. 200 Walloon families had settled in the level, who had planted a town, built a church, and had 21,000 acres of land under the plough. All were peaceable, when in 1642 their fen neighbours rose upon them, broke down the fences and enclosures of many thousand acres, destroyed the growing corn and demolished the houses, pulled up the flood-gates which let in the tides from the Trent, and drowned a great part of the Chace. Persons armed stood by all the while, and vowed they would remain until the whole level was completely under water, and parties relieved each other for seven weeks, guarding the sluices, and letting in the tides at high water. The inhabitants of Millerton pulled down other sluices, and the Trent destroyed the banks, and barns and stacks of corn stood a yard deep in water. In one manor, Epworth, 370 persons pretended to have a right of common. Vermuyden drained the whole at an expense of £26,000, and he set off 6,000 acres, lying next to the town, to these commoners, free of all charge, and to be preserved for ever, at his cost, free from floods. This land, from eight pence an acre, was made worth thirteen shillings an acre, and instead of growing sedge and reed only, it was covered with corn. These greedy, ungrateful commoners were the most violent rioters. Parliament then interfered to protect the drainers, when seven inhabitants of Epworth, led by Noddel, an attorney, filed a bill in the Exchequer against them and kept possession. The sheriff procured a writ of assistance, and came with 100 persons to the protection of the adventurers, and began to repair the banks which had been destroyed, when Noddel, who had joined himself to Colonel Lilburn and Major Wildman, heading a larger party of the fen men, forced the sheriff and his posse to fly, and demolished what he had set up. He then joined in another riot, impounded tenants' cattle, refused replevins, and forced the drainers to pay what rates he pleased for redemption. The neighbouring justices gave encouragement to these outrages. In 1650 a decree was made in the Exchequer establishing possession to the adventurers, (who had expended £300,000 in the general improvement of the level.) Lilburne and Noddel declared they would not obey it, and called the House "a parliament of clouts," and proceeded to deface the church at Santoft, and in a few days they demolished the town itself, and eighty other houses thereabouts, besides barns, stables, and outhouses; destroyed the corn on 3,400 acres, and did damage to the amount of £80,000. Lilburne and Noddel guaranteed to defend the Epworth folks from past riots, and maintain them in possession of the adventurers' allotment of 7,400 acres, on receiving 2,000 acres. Crowle, a confederate of Lilburne and Noddel, so terrified the tenants that they *took leases* from Margrave, another of the confederates, and by these means fairly ousted the drainers. Having done so, they demised portions of the level to many of their friends. Lilburne himself took possession of the dilapidated house that had been built for the minister, and repaired it, and put his servants to live in it and keep possession, and made a stable and barn of the church. In 1653 the parliament ordered the interlopers to be put down, but the fen men disregarded the order, until 1656, when Cromwell directed Whalley to set matters right, and by the aid of his soldiers the fen was made quiet, and remained so until the restoration.

his partners had *not* drained the Great Level according to the Lynn law. A tax of thirty shillings an acre was then laid on the adventurers' portion, to complete their contract, but being without funds they refused to contribute, and the king then declared himself the undertaker. He was to receive 95,000 acres, and 57,000 acres in addition of the recovered lands; and out of this he agreed to allot 40,000 acres to Earl Bedford and his partners, as compensation for the £100,000 they had expended under the Lynn law. The king engaged to make the whole level *winter lands*, which he calculated would raise their value (400,000 acres being now stated to be the marsh surface) to 600,000 pounds. Vermuyden, who is said to have made the calculation, and to have advised the king throughout, printed in 1642 an account of the system of draining which he thought it was most prudent to follow.

The king's works seem to have been directed by Vermuyden, but they were carried a very little way; the troubles in which the monarch became involved affected this project, and after expending £24,000, his operations ceased. The prospect of fen

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One Reading, a counsellor, was now appointed to collect the rates; and for £200 a year he engaged to establish the *rights* of the drainers or *participants*, as they were called, and *the rule of the law*, and thenceforth he became the object on which the hatred of the community was concentrated. On one occasion he applied for a writ of assistance from the sheriffs of three counties, "and the service being dangerous he provided horses, arms, and 20 men, and a *chirurgeon* in ordinary;" at other times his hired band required a great increase of numbers. In 1688, the fen men succeeded in depriving the participants of 3,100 acres of their allotment, but their bad spirit, nevertheless, continued, under their leader, a Mrs. Popplewell, the wife of a substantial fen man, and in 1697 an atrocious attempt was made to destroy Reading and his family. Bundles of tow were thrust under the thatch of his house roof, and fired at the dead of night. The falling of the burning thatch into the rooms awakened the family, who on trying to escape found the key-holes of all the door locks had been filled up with clay; and they must inevitably have perished, had not Colonel Reading, then on a visit to his father, managed to wrench one of the window bars (put up to secure the house from assault) from its place, and by this means opened a passage for the ladies and other members of the family, mutilated and wounded, to escape with their lives.

In 1716 Mr. Reading died in his bed, among his inveterate enemies, having reached the age of 100 years, fifty of which he passed in constant dread of personal violence, and having *fought thirty-one set battles* with the fen men in defence of the drainers' rights. This state of lawless excitement, from first to last, continued for 104 years, involved the district in constant litigation, ruined many ancient and opulent families who were drawn into the vortex of local quarrel, and led the community into the sanction and commission of great crimes; the bone of contention throughout being 6,000 *acres of land* that *never had been worth eight pence an acre* to the fen men. It has been asked what has been the final result to individuals by the cultivation of this large property by a *numerous poor* proprietary. In 1839 (210 years after drainage) the community in possession is thus described:—"Some of the small freeholders live decently and respectably, but the greater part are very poor, and far worse off than the generality of day labourers, certainly much worse than those who are constantly employed by the large agriculturists; yet the lands let from 30*s*. to 70*s*. an acre near the villages, and are sold at £80 and £100, or more, an acre."

improvement had never been so gloomy. The king was in possession and could not go on. Towns interested in the navigation were hostile to the undertaking, and some leading men in parliament strongly opposed the draining commission; and by the death of the Earl of Bedford, (in 1641,) the original adventurers were deprived not only of an experienced guide but a protector. The hostile inhabitants, taking advantage of this state of affairs, entered upon the drained lands, particularly those set out to the adventurers, and the works rapidly fell into decay and ruin.

In 1645 the original adventurers, with the Earl of Bedford (son of the late undertaker) at their head, again appeared as petitioners to parliament. According to the statement of the earl, they had expended £93,000 in principal money, and £34,170 as interest, and were owing £4,000. And in 1646 a committee drew up an ordinance for settling and draining the Great Level. So strong was the opposition to this salutary measure that forty-eight petitions were presented to the House against it from persons and places, as being a delusive scheme, hurtful to the local navigation, injurious to the fen owners, ruinous to the poor, and detrimental in numerous ways to the country. In 1647, in consequence of these petitions, it was solemnly debated in the House whether the project was feasible—and if feasible, beneficial; after hearing counsel and witnesses, it was resolved that a great part of the level might be drained; that draining was profitable to the commonwealth; that 95,000 acres should be set out from the drained lands for the expenses of doing it, and that as each 30,000 acres should be drained, a proportionate share should be set out to the adventurers.

Things remained in this state till after the king's death, in 1649, when a bill passed the House by which the original adventurers were reinstated, and provision made for settling the conflicting claims made on the company.

The system to be followed now became a subject of keen discussion at the board and with the country. Bavents Westerdyke, a great fen-draining Dutchman of these times, who was brought from Holland to give his opinion on Vermuyden's project, declared it impracticable to drain the fens by sluices, and that they must embank and improve the beds and outfalls of the natural rivers. King's Lynn petitioned in the most earnest manner against the use of sluices, and foretold the future mischiefs they would produce. Lord Gorges, a man of experience in these matters, was opposed to the system, and Vermuyden himself admitted that what he recommended in this particular case, was against the general and admitted laws of draining, as derived from experience. Yet although setting down sluices was against Magna Charta, and ten unrepealed statutes, (one of them their own act of Parliament,) against the opinion of Atkins, given thirty years before, and that of

Colonel Armstrong in 1620, and of Westerdyke now, it was decided by one vote to build sluices on the Great Ouse. An immense series of works was thus commenced on an erroneous system, which have entailed on the fen districts constant expenses, the amount of which since the commencement exceeds many times the whole value of the fen lands, but which under a better system would have all rested, as profit on their labour, in the pockets of the fen farmers.

Both the original adventurers and the king's commission seem to have fallen into arrears with Vermuyden, who on pledge or by purchase held a large portion of the lands allotted under the Lynn law, which gave him an influence that the adventurers, who felt fettered by it, had not power to set aside. They applied to him for a plan of the drainage, and a statement of the terms on which he would undertake to direct the operations, but his terms were rejected, and he would make no concession. He now began to intrigue against the company and oppose their measures; who thereupon publicly invited other engineers to bring in their plans, and apply for employment to the company. A Colonel Dobson, who had great experience in fen matters, was a candidate, but Sir Edward Partheriche was chosen director of the works by twelve out of fourteen adventurers, apparently with a view of bringing the Dutchman a little more to reason.

Vermuyden on this attacked the plan of draining proposed to be followed, and his reasons being thought better than Parthericke's, he was finally chosen director of the works. The zeal and legal knowledge of the chief justice, Oliver St. John, and the experience of Lord Gorges, and of the Earl of Arundel, who all held lots, made them invaluable assistants to the Earl of Bedford; and, in spite of pinching funds, want of labourers, and of local hostility, the works proceeded with steadiness and rapidity; and in the spring of 1651 the parliamentary commissioners certified that 170,000 acres had been drained. 58,000 acres were accordingly set out to the adventurers, as the portion due for the sum of £170,000 they had expended in forming drains and embankments.

Favourable as matters now seemed, yet some of those who had the best means of being well informed on the subject, had strong doubts of ultimate success. Among others Lord Arundel suddenly sent a message to the company, that he would pay no more taxes, and that they might dispose of his allotment as they saw fit. It surely was extraordinary that, at this prosperous period, his 5,900 acres should be sold at 3*s*. 4*d*. an acre, (£1,590,) which 17 years afterwards were bringing in £4,000 a year!

To return to Vermuyden, another portion of the drainage was undertaken, and he was continued as director. The company again became crippled, from the misappropriation of a sum of money by one of its agents; and a large body of its labourers seem to have left them, from their wages being in arrear. The company petitioned to have some of the Scotch soldiers, who had been made prisoners by Cromwell at the battle of Dunbar, and sent to England; and nearly a thousand of these brawny, raw-boned ragamuffins being supplied with shoes, stockings, and caps, and breeks to cover their nakedness, were marched into the fens, where they received from the company an abundance of food and drink, and comfortable housing. In the absurd fear of the Scots deserting this land of plenty and fatness parliament issued an order making it "death, without mercy, for anie of the Scotts to run awaie," and that "John Stan, the Provost Marshall, shoulde see martial law done on such as should be retaken." At the peace with Scotland, it was one of the "fenmen's grievances that so many of the Scotsmen remained in the level, that the poor natives were deprived of their bread." Serious riots now broke out at Swaffham, and other places, which were put down by soldiers. The works were carried through a hostile country, and labourers were had with difficulty, when a large body of the Dutch prisoners brought to England by Blake, after his battle with Van Tromp, were marched to the fens, on the same conditions as the Scotchmen. Matters were pursued so vigorously, that Vermuyden declared, at a meeting of the adventurers in 1652, that the whole unadjudged remainder of the hitherto drowned lands of the Great Level were drained within the true meaning of the act of parliament. The Lord General made the official recognition of the fulfilment of the contract an affair of much ceremony. Lords Whitelock and Lisle, with others as commissioners, were sent to the fens; the soldiers quartered at Ely formed their escort, and great preparations were made by the authorities to give their visitors a proper reception. To this assembly, met to terminate the greatest and most national commercial enterprize that had hereto been undertaken in England, Vermuyden stated, "that 40,000 acres of land formerly adjudged were at that moment sown with coleseed, wheat, and other winter grain, besides having innumerable quantities of sheep, cattle, and other stock, where never any had been before." "I presume not," continued the worthy Dutchman, with honest exultation, "to say more of the works to the meeting, lest I should be accounted vainglorious, although I might truly affirm that the present or former age have done nothing like it for the general good of the nation. I humbly desire that God may have the glory, for his blessing, and bringing to perfection, my poor endeavours, at the vast charge of the Earl of Bedford and his participants." After having viewed the level, the lords commissioners then adjudicated, and the official deed was received by the Earl of Bedford (and his partners) kneeling. A general thanks-giving was kept in the fens, and Cromwell's chaplain, Hugh Peters, preached in Ely Cathedral, before the lords commissioners and the adventurers and a great concourse of people.

The claims of the adventurers were confirmed by letters patent of incorporation, granted by Charles II., on his restoration[a], and his majesty received the 12,000 acres that were stipulated to be given to Charles I.

1652. Evelyn says, "I inspected the manner of chambling silk and grograms at one Mr. La Doree's in Morefields." Doree introduced the art.

1653. A list of some works which Mr. WILLIAM WHEELER offereth to undertake :—

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[a] A good idea of the abundance these enclosures produced in the fens is given in the following notice:— "After the lands were drained, many finding the division and cutting of the *commons* proved a *waste of ground*, and an expense for fences, they agreed they would not divide, but occupy by way of stint to feed the same, every house alike; so that in some towns there are 2,000 milch kine, besides a great running stock fed thereon, by people that formerly had nothing to live on but fishing and fowling." The owners of these cattle were inveterate enemies to the reclaimers of their common lands that fed them, and clamoured and petitioned against the marsh drainers. The following estimate was drawn out (in 1642) to show the money paid to the country people by the improvers.

Every acre for hassocking, burning hassocks, plowing, burning the soord, sowing with cole seed, 20*s*., which came into the hands of suche as would work, whether poor or rich	£28,000
Every acre of seed, wheat, barley or oats, cost 8*s*. an acre, came into the hands of the country	11,200
Small division-dykes since adjudication came clear to poor labourers	3,000
Timber, carpenters', bricklayers', and labourers' building houses	10,000
Reaping, threshing, carriage of seeds, &c., at £3 a last, to be fit for the boates, to poor labourers	2,500
Reaping, threshing, carriage of wheat, rye, oats, barley, flax, to labourers	15,000
Carriage of 5,000 last of cole seed, 1,000 of wheat and other commodities, to watermen of Lynn and Wisbech	2,700
Transportation by water of materials for houses and other works, to watermen	300
Chambering seeds and goods at Lynn, thirteen weeks	650
At Lynn to meters and porters	150
1,000 ton of seed, and other grain, to London	1,000
Expended in labour to labourers, for next year, in hassocking, sowing of crops, &c.	30,000
Custom and excise, cole seed, oyle, &c.	5,000
Total	£109,500

a year, which are the advantages from so small a portion as 28,000 acres only, exclusive of the value of the crops, stock, and merchandize of the increased population, amounting to a large sum, also expended in the neighbourhood.

"He maketh engines that, by the help of one man, have delivered 500 tuns of water in an hour, about three foot (as hath ben tried at Amsterdam). Others, 1,000 tuns, six foot high, by one horse—applied to draining of mines, ponds, fens, and to convey water to towns.

"To bore with a wooden augur faster, streighter, of a bigger boare, and withal much better and cheape.

"He passeth boates over a deepe river, running never so swift, and of great breadth, without the use of oares, saile, or ought else, that by its noise or visibilities may give notice thereof.

"He maketh beames for the weighing of extraordinary weights, by which the trouble and cost of such weighings may be much abated; and doth more by cranes than is anywhere usually done.

"Better tooles for dispatch, cheapness, and exact working; as saws, whereby ovals, sphaeres, or any portions or segments of them, may, with one sweepe of the same, be taken out of a body of timber or other material, so that washing bowles, cupps, may be more quickly and incomparably made than is ordinarily done.

"Instruments for forming of stone into all manner of regular figures, whether right-lined, circular, or mixt, and the polishing of them.

"Fulling mills which, with half the strength of men or horses, are equivalent in strength and effect to the common ones moved by wind or water.

"Such helpes to a ship already built as shall enable it to saile more speedily in a calme, or smal gale, and more safely in a storme.

"An artifice to supply the want of a rudder, in case it be carried away; and substitutes a device in place thereof, that shall satisfy the intentions of a rudder more effectualy.

"He can in a manner secure a ship from being boarded by an enemie, and yet have great advantages to board them, which is the business of all other the most important in sea fights.

"A fort moveable and easily transportable, furnished with 12 pieces of ordnance, in which gunners will be secure from their enemies' shot, and the soldiery exempt from annoyance of smoke; the labour of discharging the guns lessened; their traversing and levelling compleatly performed with small and easy motions.

"A colony defensible within 48 houres after first landing of planters, to prevent the assaults of the natives, who are most plentiful upon the richest groundes, which is a mighty discommodity to young beginners.

"Carts of a new fashion, to transport great burthens from place to place. The old ones spoile goode wayes, by making holes, cart routes in them, to the extreme prejudice of the poor cattle that drawe them; to the vexation of the drivers, who, with their horses and carriages, are often stuck fast in a bog. These inventions shall plaine, level, and strengthen the said wayes, as if their whole use were but to mend what the others have undone and spoiled.

"He takes away the common loathsome discommodities of highways, and makes the worst of them, the great roades within a mile or two of London, like pleasant promenadoes and walks of recreation, in all kinds of weather; from want whereof, most great and faire cities may be deservedly called foule and unwholesome jakes and dunghills.

"He undertakes to make the cittie of London a very faire, sweete, and pleasant cittie; within a week's time so cleane within, that one may walke in slippers in all weathers, except snow, in the foulest streets thereof, and can settle in a way whereby it may be preserved with lesse than half an hour's labour a daye; so that houses scarce kept sufficiently cleane with two servants, may, by his direction, be put into that condition with one, to the great preservation of cloths and shoeleather. The charge of scavengers shall be much lessened; the dirt shall be converted to other uses; and that water which fowles the said river shall cleanse the land upon all occasions, and the water preserved in repositories or cisterns, to run of themselves whethersoever the necessity of quenching fires calls them; and the confusion and waste of breaking up streets, opening water pipes, shall wholly cease.

"Bells that may be rung with far lesse strength than usual, whereby we may oftner hear pleasant noise of bells without a tumult of ringers.

"Nourishing and cultivating outlandish plants and trees here at home, so as to make them flourish as in their own proper soil; to make our domestic fruit more fruitful; to accelerate the budding and opening of flowers out of their natural seasons, and to make arbours.

"He can discover a certaine woode, hitherto wholly neglected and despised, fit for timber, faire, tough, and durable, free from wormes, not subject to rott, either in the wet or dry, fitt for water conduits, good for all joiners' workes, particularly for wainscot, and withal very light of carriage.

"A certain cement which may be moulded into anie figure, and being polished, is so hard that no ordinary stone tooles will touch it; very beautefull and dureable, and of a very reasonable rate.

"Walls as firme and substantial as those of stone and brick, and, with a little paines, as beautyfulle, of pebblestones, gravel, or such like rubbish; and with this matter he can counterfiet either brick or stone, at a very easy rate.

"To preserve beefe, mutton and venison a twelvemoneths from stinking; he can so reduce tainted meats, that the most discerning palate shall never be sensible of any such defect.

"Where meates will either not take salt at all, or putrifie being salted, he can remedie both the one and other inconvenience.

"Where all convenient materials seeme to be wanting, he undertakes, nevertheless, to build a fort cannon proofe.

"Sea breaches more speedily and firmly repaired than hitherto practised.

"Hee will raise a fountain out of level ground, cheaper than others brought from adjacent hills, no way inferior to them in beauty, and high throwing of the water.

"He can secure the banks of drained, turfed lands, which are subject to dry or burne away in summer, or to be burnt up by mischievous people, or subside or sinke in winter; he can secure such works from inconveniences.

"He can make these bankes so as, by what they shall produce, to defray the charge of their making.

"He can drive great piles into the ground without beetles, or the usual moliminous instruments.

"Glory be to God, the father of lights. Wisdom is better than strength, wisdome is better than weapons of war."

Wheeler says he had been engaged in Norfolk and Suffolk, as an engineer for sea breaches, draining of fens, architecture, plantations; but finding that the name of a traveller and the foreign acquisition of skill did add that credit and repute to artists which no native is allowed in his own country, among his kindred and acquaintance, he embarked for Holland, to improve his abilities, or the value of his abilities, by conversing with strangers. He had some Dutch patents for his schemes.

Before 1654, WILLIAM BURROUGHS, city founder in Lothbury, had so completed the fire engine introduced by Jones, that his additions amounted to a new invention. He made it more secure from breaking, and easie to be cleaned, so that with the striking out of a wedge it cleaned itself and was fit to work again in four minutes. "He hath made," says Fuller, "about threescore of these engines for city and country. The cooper, carpenter, smith, founder, brazier, and turner, contribute their skill to the perfecting of it, yet may the price thereof be compassed for 35 pounds. It hath gained because it hath saved many pounds, and which is invaluable many lives of men in this city. The best, though not the biggest, was lately in the Church of St. James, at Clerkenwell, as hath been many times experimented—a good musician makes a good instrument—and it was a poor blue cap (better known by his work than name) who played so well thereon, that, though not with the left-handed Gibeonites, to hit the mark within a hair's breadth, he could hit within the scantling of a shilling. Since a newer at St. Bride's Church is better, it is no wonder if the younger outvie those who are more ancient. All wished this engine might be brought out once a quarter, to be scoured, oyled, and trimmed, but not used—but if there be occasion thereof, urged effectually perform that for which it was intended." A few years after this the great fire destroyed both the engines and the buildings.

1655. The name of the Marquis of Worcester is, perhaps, one of the best known in the history of English mechanical invention. He was the first who gave a clear and minute description of the invention of the steam engine, and he seems to have carried his invention into practice. His account of it forms the propositions numbered 63, 98, 99, 100, in the following catalogue which he has left us of a hundred of his inventions.

A Century of the Names and Scantlings of such Inventions, as at present I can call to mind to have tried and perfected, which (my former notes being lost) I have, at the instance of a powerful friend, endeavoured now, in the year 1655, to set these down in such a way as may sufficiently instruct me to put any of them in practice.

1. Several sorts of seals, some shewing by scrues, others by gages fastening or unfastening all the marks at once; others by additional points and imaginary places proportionable to ordinary escocheons, and seals at arms, each way palpably and punctually setting down (yet private from all others but the owner, and by his assent) the day of the moneth, the day of the week, the moneth of the year, the year of our Lord, the names of the witnesses, and the individual place where any thing was sealed, though in ten thousand several places, together with the very number of lines contained in a contract, whereby falsification may be discovered and manifestly proved being upon good grounds suspected.

Upon any of these seales a man may keep accompts of receepts and disbursements from one farthing to an hundred millions, punctually shewing each pound, shilling, peny, or farthing. By these seals, likewise, any letter, though written but in English, may be read and understood in eight several languages, and in English itself to seem contrary and different sense unknown to any but the correspondent, and not to be read or understood by him neither, if opened before it arrive unto him, so that neither threats nor hopes of reward can make him reveal the secret, the letter having been intercepted, and first opened by the enemy.

2. How ten thousand persons may use these seals, to all and every of the purposes aforesaid, and yet keep their secrets from any but whom they please.

3. A cypher and character so contrived that one line, without returns and circumflexes, stands for each and every of the 24 letters, and as ready to be made for the one letter as the other.

This invention refined and so abreviated that a point onely sheweth distinctly, and significantly, any of the 24 letters, and these very points to be made with two pens, so that no time will be lost, but as one finger riseth, the other may make the following letter, never clogging the memory with several figures for words, and combinations of letters, which, with ease and void of confusion, are thus speedily and punctually letter for letter set down by naked and not multiplied points; and nothing can be less than a point, the mathematical definition being *cujus pars nulla*, and of a motion no swifter imaginable than semiquavers or releshes, yet applicable to this manner of writing.

5. A way by a circular motion, either along a rule or ringwise, to vary the alphabet, even this of points, so that the selfsame point individually placed, without the least additional mark or variation of place, shall stand for all the 24 letters, and not for the same letter twice in ten sheets writing, yet as easily and certainly read and known as if it stood but for one and the selfsame letter constantly signified.

6. How at a window, as far as eye can discover black from white, a man may hold discourse with his correspondent, without noise made or notice taken; being according to occasion given, and means afforded. *Ex* re natâ, and no need of provision beforehand; though much better if foreseen and means prepared for it, and a premeditated course taken by mutual consent of parties.

7. A way to do it by night as well as by day, though as dark as pitch is black.

8. A way how to level and shoot cannon by night as well as by day, and as directly; without a platform or measures taken by day, yet by a plain and infallible rule.

9. An engine, portable in one's pocket, which may be carried and fastened on the outside of the greatest ship, *tanquam* ALIUD AGENS, and at any appointed minute, though a week after, either of day or night, it shall irrecoverably sink that ship.

A way, from a mile off, to dive and fasten a like engine to any ship, so as it may punctually work the same effect either for time or execution.

11. How to prevent and safeguard any ship from such an attempt, by day or night.

12. A way to make a ship not possible to be sunk, though shot an hundred times betwixt wind and water by cannon, and should lose a whole plank, yet in half an hour's time should be made as fit to sail as before.

13. How to make such false decks as in a moment should kill and take prisoners as many as should board the ship, without blowing the decks up or destroying them, from being reducible; and in a quarter of an hour's time should recover their former shape, and to be made fit for any employment without discovering the secret.

14. How to bring a force to weigh up an anchor, or to do any forcible exploit, in the narrowest or lowest room in any ship, where few hands shall do the work of many; and many hands applicable to the same force, some standing, others sitting, and by virtue of their several helps a great force augmented in a little room, as effectual as if there were sufficient space to go about with an axle tree, and work far from the centre.

15. A way how to make a boat work itself against wind and tide, yea, both without the help of man or beast; yet so that the wind or tide, though directly opposite, shall force the ship or boat against itself; and in no point of the compass, but it shall be as effectual as if the wind were in the pupp, or the stream actually with the course it is to steer, according to which the oars shall row, and necessary motions work and move towards the desired port or point of the compass.

16. How to make a sea-castle or fortification cannon proof, and capable of a thousand men, yet sailable at pleasure to defend a passage, or in an hour's time to divide itself into three ships, as fit and trimmed to sail as before; and even whilest it is a fort or castle they shall be unanimously steered, and effectually be driven by an indifferent strong wind.

17. How to make upon the Thames a floting garden of pleasure, with trees, flowers, banquetting houses, and fountains, stews for all kind of fishes, a reserve for snow to keep wine in, delicate bathing places and the like, with music made with mills; and all in the middest of the stream, where it is most rapid. An artificial fountain to be turned like an hour-glass by a child in the twinkling of an eye, it holding great quantity of water, and of force sufficient to make snow, ice, and thunder, with a chirping and singing of birds, and shewing of several shapes and effects usual to fountains of pleasure.

19. A little engine within a coach whereby a child may stop it, and secure all persons within it, and the coachman himself, though the horses be never so unruly in a full career; a child being sufficiently capable to loosen them, in what posture soever

they shall have put themselves, turning never so short; for a child can do it in the twinkling of an eye.

20. How to bring up water balance wise, so that as little weight or force as will turn a balance will be onely needful, more then the weight of the water within the buckets, which counterpoised empty themselves one into the other, the uppermost yielding its water (how great a quantity soever it holds) at the self same time the lowermost taketh it in, although it be an hundred fathom high.

21. How to raise water constantly with two buckets onely day and night, without any other force then its own motion, using not so much as any force wheel or sucker, nor more pullies then one on which the cord or chain rolleth with a bucket fastened at each end. This, I confess, I have seen and learned of the great mathematician, Claudius, his studies at Rome, he having made a present thereof unto a cardinal, and I desire not to own any other men's inventions; but if I set down any, to nominate likewise the inventor.

22. To make a river in a garden to ebbe and flow constantly, though twenty foot over, with a child's force, in some private room or place out of sight, and a competent distance from it.

23. To set a clock in a castle, the water filling the trenches about it, it shall shew by ebbing and flowing the hours, minutes, and seconds, and all the comprehensible motions of the heavens, and counter libation of the earth according to Copernicus.

24. How to encrease the strength of a spring to such an height as to shoot bumbasses and bullets of an hundred pound weight a steeple height, and a quarter of a mile off and more, stonebow wise, admirable for fireworks and astonishing of besieged cities, when, without warning given by noise, they find themselves so forcibly and dangerously surprised.

25. How to make a weight that cannot take up an hundred pound and yet shall take up two hundred pound, and at the self same distance from the centre, and so proportionably to millions of pounds.

26. To raise weight as well and as forcibly with the drawing back of the lever, as with the thrusting it forwards; and by that means to lose no time in motion or strength. This I saw in the Arcenal at Venice.

27. A way to remove to and fro huge weights with a most inconsiderable strength from place to place. For example, ten tunne with ten pounds and less; the said ten pounds not to fall lower then it makes the tunne to advance or retreat upon a level.

28. A bridge portable in a cart with six horses, which in a few hours' time may

be placed over a river half a mile broad, whereon with much expedition may be transported horse, foote, and cannon.

29. A portable fortification able to contain five hundred fighting men, and yet in six hours' time may be set up and made cannon proof upon the side of a river or pass, with cannon mounted upon it, and as complete as a regular fortification, with halfmoons and counterscarps.

30. A way in one night's time to raise a bulwork twenty or thirty foot high, cannon proof and cannon mounted upon it, with men to overlook, command, and batter a towne, for though it contain but four pieces they shall be able to discharge two hundred bullets each hour.

31. A way how safely and speedily to make an approach to a castle or town wall, and over the very ditch, at noonday.

32. How to compose an universal character, methodical and easie to be written, yet intelligible in any language, so that if an Englishman write it in English, a Frenchman, Italian, Irish, Welsh, being scholars, yea Grecian or Hebritian, shall as perfectly understand it in their owne tongue as if they were perfect English, distinguishing the verbs from nouns, the numbers, tenses, and cases, as properly expressed in their own language as it was written in English.

33. To write with a needle and thred, white or any colour upon white or any other colour, so that one stitch shall significantly shew any letter, and as readily and as easily shew the one letter as the other, and fit for any language.

34. To write by a knotted silk string, so that every knot shall signifie any letter, with comma, full point, or interrogation, and as legible as with pen and ink upon white paper.

35. The like by the fringe of gloves.

36. By stringing of bracelets.

37. By pinck'd gloves.

38. By holes in the bottom of a sieve.

39. By a lattin or plate lanthorn.

40. By the smell.

41. By the taste.

42. By the touch.

By these three senses as perfectly, distinctly, and unconfusedly, yea as readily as by the sight.

43. How to vary each of these, so that ten thousand may know them, and yet keep the understanding part from any but their correspondent.

44. To make a key of a chamber door which to your sight hath its wards and rosepipe but paper thick, and yet at pleasure, in a minute of an hour, shall become a perfect pistol, capable to shoot through a brestplate, commonly of carabine proof, with prime, powder, and fire-lock, undiscoverable in a stranger's hand.

45. How to light a fire and a candle at what hour of the night one awaketh, without rising or putting one's hand out of the bed, and the same thing becomes a serviceable pistol at pleasure, yet by a stranger not knowing the secret seemeth but a dexterous tinder-box.

46. How to make an artificial bird, to fly which way and as long as one pleaseth, by or against the wind, sometimes chirping, other times hovering, still tending the way it is designed for.

47. To make a ball of any metal, which thrown into a pool or pail of water shall presently rise from the bottom, and constantly shew, by the superficies of the water, the hour of the day or night, never rising more out of the water then just to the minute it sheweth of each quarter of the hour; and if by force kept under water, yet the time is not lost but recovered as soon as it is permitted to rise to the superficies of the water.

48. A scrued ascent instead of stairs, with fit landing-places, to the best chambers of each story, with back stairs within the swell of it, convenient for servants to pass up and down to the inward rooms of them, unseen and private.

49. A portable engine in way of a tobacco tongs, whereby a man may get over a wall, or get up again, being come down, finding the coast proving insecure to him.

50. A complete light portable ladder, which, taken out of one's pocket, may be by himself fastened an hundred foot high to get up by from the ground.

51. A rule of gradation which with ease and method reduceth all things to a private correspondence, most useful for secret intelligence.

52. How to signifie words, and a perfect discourse, by jangling of bells of any parish church, or by any musical instrument within hearing, in a seeming way of tuning it, or of an unskilful beginner.

53. A way how to make a hollow and cover a water scrue as big and as long as one pleaseth, in an easie and cheap way.

54. How to make a water scrue tite and yet transparent, and free from breaking; but so clear that one may palpably see the water, or any heavy thing, how and why it is mounted by turning.

55. A double water scrue, the innermost to mount the water, and the outermost for it to descend more in number of threds, and consequently in quantity of water,

though much shorter than the innermost scrue by which the water ascendeth; a most extraordinary help for the turning of the scrue to make the water rise.

56. To provide and make that all the weights of the descending side of a wheel shall be perpetually further from the centre than those of the mounting side, and yet equal in number and kept to the one side as the other; a most incredible thing if not seen, but tried before the late king (of blessed memory) in the Tower, by my directions; two extraordinary embassadors accompanying his majesty, and the Duke of Richmond and Duke of Hamilton, with most of the court, attending him. The wheel was 14 foot over, and 40 weights of 50 pounds apiece. Sir William Balfore, then Lieutenant of the Tower, can justifie it with several others. They all saw that no sooner these great weights passed the diameter line of the lower side but they hung a foot further from the centre, nor no sooner passed the diameter line of the upper side but they hung a foote nearer; be pleased to judge the consequence.

57. An ebbing and flowing water-work in two vessels, into either of which, the water standing at a level, if a globe be cast in, instead of rising it presently ebbeth, and so remaineth until a like globe be cast into the other vessel, which the water is no sooner sensible of but that vessel presently ebbeth and the other floweth, and so continueth ebbing and flowing until one or both of the globes be taken out, working some little effect besides its own motion, without the help of any man within sight or hearing; but if either of the globes be taken out with ever so swift or easie a motion, at the very instant the ebbing and flowing ceaseth; for if during the ebbing you take out the globe, the water of that vessel presently returneth to flow, and never ebbeth after until the globe be returned into it, and then the motion beginneth as before.

58. How to make a pistol to discharge a dozen times with one loading and without so much as once new priming requisite, or to change it out of one hand into the other, or stop one's horse.

59. Another way as fast and effectual, but more proper for carabines.

60. A way with a flask appropriated unto it, which will furnish either pistol or carabine with a dozen charges in three minutes' time, to do the whole execution of a dozen shots, as soon as one pleaseth proportionably.

61. A third way, and particular for musquets, without taking them from their rests, to charge or prime to a like execution and as fast as the flask, the musquet containing but one charge at a time.

62. A way for a harquebuss, a crock, or ship musquet, six upon a carriage, shooting with such expedition as without danger one may charge, level and discharge them sixty times in a minute of an hour, two or three together.

63. A sixth way, most excellent for sakers, differing from the other yet as swift.

64. A seventh, tried and approved before the late king (of ever blessed memory) and an hundred lords and commons, in a cannon of 8 inches half quarter, to shoot bullets of 64 pounds weight, and 24 pounds of pouder, twenty times in six minutes, so clear from danger, that after all were discharged a pound of butter did not melt, being laid upon the cannon britch, nor the green oile discoloured that was first anointed and used between the barrel thereof, and the engine having never in it, nor within six foot, but one charge at a time.

65. A way that one man in the cabin may govern the whole side of ship musquets, to the number (if need require) of 2 or 3,000 shots.

66. A way that, against several advenues to a fort or castle, one man may charge fifty cannons playing, and stopping when he pleaseth, though out of sight of the cannon.

67. A rare way, likewise, for musquettoons fastened to the pummel of the saddle, so that a common trooper cannot misse to charge them with twenty or thirty bullets at a time, even in full career.

When I first gave my thoughts to make guns shoot often, I had thought there had been but one onely exquisite way inventible; yet, by several trials and much charge, I have perfectly tried all these.

68. An admirable and most forcible way to drive up water by fire, not by drawing or sucking it upwards, for that must be, as the philosopher calleth it, *intra sphaeram activitatis*, which is, but at such a distance. But this way hath no bounder, if the vessels be strong enough; for I have taken a piece of a whole cannon, whereof the end was burst, and filled it three quarters full of water, stopping and scruing up the broken end, as also the touch hole, and making a constant fire under it, within 24 hours it burst and made a great crack. So that having a way to make my vessels so that they are strengthened by the force within them, and the one to fill after the other, I have seen the water run like a constant fountaine stream forty foot high; one vessel of water rarefied by fire driveth up forty of cold water; and a man that tends the work is but to turn two cocks, that one vessel of water being consumed, another begins to force and refill with cold water, and so successively the fire being tended and kept constant, which the selfsame person may likewise abundantly perform in the interim between the necessity of turning the said cocks.

69. A way how a little triangle scrued key, not weighing a shilling, shall be capable and strong enough to bolt and unbolt, round about a great chest, an hundred bolts through fifty staples, two in each, with a direct contrary motion, and as many more from both sides and ends, and at the selfsame time shall fasten it to the place

beyond a man's natural strength to take it away; and in one and the same turn both locketh and openeth it.

70. A key with a rose turning pipe, and two roses pierced through endwise the bit thereof, with several handsomely contrived wards, which may likewise do the same effects.

71. A key perfectly square, with a scrue turning within it, and more conceited then any of the rest, and no heavier then the triangle scrued key, and doth the same effects.

72. An escocheon, to be placed before any of these locks, with these properties.

1. The owner (though a woman) may with her delicate hand vary the wayes of coming to open the lock ten millions of times beyond the knowledge of the smith that made it, or of me who invented it.

2. If a stranger open it, it setteth an alarm agoing which the stranger cannot stop from running out; and besides, though none should be within hearing, yet it catcheth his hand as a trap doth a fox, and though far from maiming him, yet it leaveth such a mark behind it as will discover him if suspected; the escocheon or lock plainly shewing what monies he hath taken out of the box, to a farthing, and how many times opened since the owner had been in it.

73. A transmittable gallery over any ditch or breach in a town wall, with a blinde and parapit cannon proof.

74. A door, whereof the turning of the bar, with the help and motion of the handle, makes the hinges to be of either side, and to open either inward or outward as one is to enter or to go out, or to open in half.

75. How a tape or ribbon weaver may set down a whole discourse without knowing a letter, or interweaving any thing suspicious of other secret then a new fashioned ribbon.

76. How to write in the dark as streight as by day or candle light.

77. How to make a man to fly, which I have tried with a little boy of ten years old in a barn, from one end to the other on an hay mow.

78. A watch to go constantly and yet needs no other winding from the first setting on the cord or chain, unless it be broken, requiring no other care from one then to be now and then consulted with concerning the hour of the day or night; and if it be laid by a week together it will not erre much, but the oftner looked upon the more exact it sheweth the time of the day or night.

79. A way to lock all the boxes of a cabinet (though never so many) at one time which were by particular keys, appropriated to each lock, opened severally and in-

dependent the one of the other, as much as concerneth the opening of them, and by these means cannot be left opened unawares.

80. How to make a pistol barrel no thicker then a shilling, and yet able to endure a musquet proof of powder and bullet.

81. A combe conveyance, carrying of letters without suspicion, the head being opened with a needle scrue, drawing a spring towards them, the comb being made but after an usual form carried in ones pocket.

82. A knife, spoon or fork, in an usual portable case, may have the like conveyances in their handles.

83. A rasping mill for hartshorn, whereby a child may do the work of half-a-dozen men commonly taken up with that work.

84. An instrument whereby persons ignorant in arithmetick may perfectly observe numerations and substractions of all summes and fractions.

85. A little ball made in the shape of plum or pear, being dexterously conveyed into a bodies mouth, shall presently shoot forth such and so many bolts of each side, and at both ends, as without the owners key can neither be opened or filed off, being made of tempered steel, and as effectually locked as an iron chest.

86. A chair made *alamode*, and yet a stranger being perswaded to sit down in it, shall have immediately his armes and thighs locked up beyond his own power to loosen them.

87. A brass mold to cast candles, in which a man may make 500 dozen in a day, and adde an ingredient to the tallow which will make it cheaper, and yet so that the candles shall look whiter and last longer.

88. How to make a brazen or stone head in the midst of a great field or garden so artificial and natural, that though a man speak never so softly, and even whispers into the ear thereof, it will presently open its mouth and resolve the question in French, Latine, Welsh, Irish, or English, in good terms, uttering it out of his mouth, and then shut it untill the next question be asked.

89. White silk knotted in the fingers of a pair of white gloves, and so contrived without suspicion, that playing at primero at cards one may, without clogging his memory, keep reckoning of all sixes, sevens and aces which he hath discarded.

90. A most dexterous dicing box, with holes transparent, after the usual fashion, with a device so dexterous, that with a knock of it against the table the four good dice are fastened, and it looseneth four false dice, made fit for his purpose.

91. An artificial horse, with saddle and caparisons fit for running at the ring, on which a man being mounted with his lance in his hand, he can at pleasure make him

start and swiftly run his career, using the decent posture with *bon grace*, may take the ring as handsomely and running as swiftly as if he rode upon a barbe.

92. A scrue made like a water-scrue, but the bottom made of iron plate, spadewise, which at the side of the boat emptieth the mud of a pond or raiseth gravel.

93. An engine whereby one man may take out of the water a ship of 500 tun, so that it may be calked, trimmed and repaired without need of the usual way of stocks, and as easily let it down again.

94. A little engine, portable in ones pocket, which placed to any door, without any noise but on crack, openeth any door or gate.

95. A double crossbow, neate, handsome and strong, to shoot two arrows, either together or one after the other, so immediately that a deer cannot run two steps but if he miss of one arrow he may be reached with the other, whether the deer run forward, sideward, or start backward.

96. A way to make a sea-bank so firm and geometrically strong that a stream can have no power over it; excellent likewise to save the pillar of a bridge, being far cheaper and stronger than stone walls.

97. An instrument whereby an ignorant person may take any thing in perspective as justly and more than the skilfullest painter can do by his eye.

98. An engine so contrived, that working the *primum mobile* forward or backward, upward or downward, circularly or corner-wise, to and fro, streight, upright or downright, yet the pretended operation continueth and advanceth, none of the motions above mentioned hindering, much less stopping, the other, but unanimously and with harmony agreeing, they all augment and contribute strength unto the intended work and operation: and therefore I call this a *semi omnipotent engine*, and do intend that a model thereof be buried with me.

99. How to make one pound weight to raise an hundred as high as one pound falleth, and yet the hundred pound descending doth what nothing else than one hundred pound can effect.

100. Upon so potent a help as these two last mentioned inventions, a water work is, by many years' experience and labour, so advantageously by me contrived, that a child's force bringeth up an hundred foot high an incredible quantity of water, even two foot diameter, so naturally, that the work will not be heard even into the next room, and with so great ease and geometrical symmetry, that though it work day and night from one end of the year to the other, it will not require forty shillings reparation to the whole engine, nor hinder one's daywork; and I may boldly call it *the most stupendeous work in the whole world.* Not onely with little charge to drein all sorts of mines and furnish cities with water, though never so high seated,

as well to keep them sweet, running through several streets, and so performing the work of scavengers, as well as furnishing the inhabitants with sufficient water for their private occasions, but likewise supplying rivers with sufficient to maintaine and make them portable from towne to towne, and for the bettering of lands all the way it runs, with many more advantageous and yet greater effects of profit, admiration and consequence; so that deservedly I deem this invention to crown my labours, to reward my expenses, and make my thoughts acquiesce in way of further inventions.

This making up the whole century, and preventing any farther trouble to the reader for the present, meaning to leave to posterity a book wherein, under each of these heads, the means to put in execution and visible trial all and every of these inventions, with the shape and form of all things belonging to them, shall be printed by brass plates.

In bonum publicum et ad majorem dei gloriam.

1656. The Rump Parliament and Cromwell abolish all kinds of monopolies. The right to dig for saltpetre was given up, and also to the exclusive monopoly of alum. The proprietors of the alum fields shortly pursued the work at five different places; Lord Mulgrave had two works, Sir William Darcey, Mr. Fairfax, and Sir Hugh Cholmley had also manufactories; and such was their emulation to undersell one another, that in 1662 alum had fallen to £13 a ton. Under the monopoly it was £26. In 1811 the average price was £26 a ton.

1660. The number of printing houses and master printers encreased to triple the number or 60, which they amounted to twenty years ago. "Never," says a cotemporary, "was there such an honourable, ingenious, profitable mystery and science in the world so basely intruded upon and disesteemed, so carelessly regarded, so unworthily subjected to infamy and disgrace by being made so common as printing hath been since 1640, in the days of our miserable confusions and calamities."

1661. Live sheep, woollen yarn, fuller's earth and clay not to be exported. The laws against using logwood in dying repealed, as the dyers had now found means to make fast the colours they dyed with it.

The silk trade now employs 40,000 persons in its various branches.

The capmakers at Bewdley are reckoned the poorest community in England.

1662. The great trade of cutting logwood in the Bay of Campeachy begun.

"Dr. Knuffler had an engine to blow up ships. The matter of fact was not questioned, as a project of this kind had been tried by some one in Cromwell's time;

but the safety of carrying them in ships being doubted, the Doctor said when he told his secret to the king, (for none but the king was to know it,) it would appear to be of no danger at all."

1663. "Sir William Petty this year invented his double ship, against the judgement and resolution of all mankind." It was built on two keels, and had about 30 tons burden and carried 30 men, with as good accommodation, or rather a great deal better, than any other ship of her burden. She also carried 10 guns, in all about five tons weight. The Experiment seems to have been built at Deptford. "The king and the Duke of York were present at the launch, when the vessel was observed to swim finely, with an odd appearance, though not so odd as people said it was." A contemporary notices going after the launch at noon to the "Royal Oak Tavern, in Lombard Street, where Sir William Petty and the owners of the *Experiment* did entertain Lord Brounker and others with marrow bones and a chine of beef of the victuals they have made for this ship; thence to Whitehall, where in the duke's chamber the king came and stayed an hour or two, laughing at Sir William Petty and his boat. Petty offered to take odds against the king's best boats; but the king would not lay, but cried him down with words only."

The Experiment was sent to Ireland. On the first trip from Dublin to Holyhead, she remained some days before her return, "and it was pleasant to consider how her adversaries insulted, and having established the conclusion that she was cast away, did afterwards discourse the several necessities why it should be so. Some said it was impossible her mast could be sufficiently planted against a strong gale, others that she was gone to Brasile. But her return in triumph with those visible advantages above other vessels did check the derision of some, and becalm the violence of others; the first point having been clearly gained, that she could bear the seas. She turned in against wind and tide into that narrow harbour amongst the rocks and ships with such dexterity, as many ancient seamen did then confess they had never seen the like. About the same time, the Earl of Ossory and other persons of honour were embarked in her, and drove to, and again, within the bar near Dublin. It then blew very hard, insomuch that a small Holland vessel famous for a good sailer, which set sail with her, was in appearance after looked upon to be overset, whilst she inclined not above half a foot more to one side than another, so that it was truly then called "the pad of the sea;" and it appeared very much to excell all other forms of ships in sailing, in carriage, in security and many other benefits. Sir William won a wager of £50 in a match between Dublin and Holyhead with the packet boat, the best ship or vessel the king had there, the Experiment coming in an hour and a half before her opponent; and Sir William offered to wager again against any ship in the world.

In a letter he wrote at this time he says, "I only affirme that the perfection of sayling lies in my principle, finde it out who can."

The Experiment was lost in "such a dreadfull tempest as overwhelmed a great fleet the same night. So that the ancient fabric of ships had no reason to triumph over the new model, when of 70 ships in the same storm not one escaped to tell the news." Sir William could not get the king's permission to build another ship, "because the Experiment had been lost, and her model was unsafe and dangerous."

A saw mill abandoned that had been erected by a Dutchman near London, in consequence of the trade hostility.

An act passed to enable Edward, Marquess of Worcester, to receive the benefit and profit of a water commanding engine, by him invented, says—"Whereas the right honourable Edward, Marquess of Worcester, hath affirmed to the king's most excellent majesty, that he hath by long and indefatigable pains and study, and with great and vast expenses, invented and found out a secret in nature never heretofore discovered, being a water commanding engine, of greater force and advantage than hitherto hath been known; and being no pump or force now in use, nor working by any suckers, barrels, or bellows, heretofore used for the raising and conveying of water, which said engine will yield very great benefit and advantage to the commonwealth." The act grants him all the profit, except a tenth part to the king, for 99 years, on condition "that a MODEL thereof be delivered by the said marquess, or his assigns, to the Lord Treasurer, or Commissioners for the Treasury for the time being, at or before the nine and twentieth day of September, one thousand six hundred and sixty-three, and be by him or them then put into the Exchequer and kept there."

Three *toll gates* or turnpikes made in Herts, Cambridge and Huntingdonshire, which were about the first direct attempts to make those actually using a road pay a toll to keep it in repair.

1665. Two individuals caused large quantities of cyder to be sent from Herefordshire, to London *ready bottled.* The beverage became popular, and the trade so flourishing, that six glasshouses were built to supply the bottles. It was sent to Lechlade and thence to London by water.

1666. In order to encourage the woollen manufacture, all dead bodies are to be buried in woollen dresses. This was considered "a most patriotic act, as linen fabrics mostly came from beyond seas, and their use was of benefit only to our natural enemies."

1668. Fashion so entirely in favour of French fabrics, that it became a complaint that women's hats were turned into hoods made of French silk, whereby every maid servant became a standing revenue to the French king of one half of her wages.

1669. A sowing machine invented by Locatelli, described by Evelyn.

Upwards of 23,680 lbs. of linen yarn imported from Scotland into the Port of London.

1670. In consequence of Archbishop Laud's persecution, upwards of 140 families out of Norfolk and Suffolk settled themselves at Leyden and Alkmar, and other parts of Holland, and there established or confirmed the woollen manufactories of those places. They were kindly received by the Dutch, who exempted them from excise and payment of house rent.

The linen manufacture began to be encouraged in Ireland, particularly among the Scots in the North; before this they sent their yarn to England to be made into cloth.

Muslins, chintzes and calicoes introduced from India by the East India Company. From their beauty and novelty they became highly fashionable for ladies' and children's dresses, instead of cambrics and fine flaxen cloths, and were used for furniture and draperies of every description, and the coarse calicoes were used for lining garments. An author of this period says, "Instead of green serg wont to be used for children's frocks is now used painted and Indian stained and striped calico, and instead of a perpetuana or shalloon to line men's coats with, sometimes is used a bangale that is brought from India for linings to coats and petticoats too."

Indian wrought silks, from their elegance and cheapness, now begin to exclude the Italian and French silks from the market.

Saltpetre, brought in large quantities from Eastern countries, is also affecting the home manufacture.

A great many glass blowers and glass cutters and polishers came to England under the patronage of the Duke of Buckingham. A manufactory was begun at Vauxhall by Bowles and Dawson, which produced blown glass in large plates, and of excellent quality.

A company was formed to manufacture tin plate. "They sent an ingenious man, Andrew Tarranton, to Saxony to learn the art of tinning, which was there carried to great perfection. After having acquired the necessary knowledge, he returned to England with some German workmen, and manufactured tin plate which received general approbation. Before the company, however, could carry on business on an extensive scale, a man of some distinction made himself acquainted with Tarranton's process, and obtained a patent for this art; and the first undertakers were obliged to give up their enterprize, which had cost them a great deal of money; and yet no use was made of the patent which had been obtained."

1673. "The new invention for sheathing ships against the worm, &c., with lead and lacker having been experimented for three years with good success and approbation, shipbuilders, merchants, and others, desirous of information regarding it, are referred to the Jerket's Office in the Custom House. This way of sheathing is much more cheap and practicable than any way hitherto used."

SIR S. MORLAND's pump. "In September his Majesty, attended by the principal officers of the navy and divers persons of quality, went to Woolwich to see the working of two water engines, invented by Sir Samuel Morland, who of late years hath not unsuccessfully applied his studies to things of practice and public use, and his Majesty was so far satisfied of their usefulness (one man performing more by these engines than eight men by the common chain pump or other engine now in use), besides that they are of a small charge, and not easy to be put out of order in many years, hath ordered one of these engines to be carried to Chatham, to empty and clear the dock of water, which no engineer or artist could ever yet do effectually, as a thing which will be no small advantage to his shipping and service, and intends also that some of these pumps shall be put up in all his ships, great and small, and the chain pump and hand pump now in use be wholly laid aside."

1674. Patent to — for the ROYAL CARROUZEL. A new and extraordinary invention for teaching handsomely to sit on horseback, dexterity in handling the lance, in running the ring, casting the javelin, and other like exercises of the academy; with the invention of running the square course, the first that ever was seen of this nature. The price was a shilling, and a course of six turns was had at the same rate.

Patent to SIR SAMUEL MORELAND. A small durable pump for private houses, taking up no more roome than an ordinary jack, and yet delivering as much water as an ordinary pump, with the strength of a child—the price 5 pound.

A large pump, delivering with half a man's strength 10 tun of water an hour, 26 foot high. The price in lead 26 pound, in wood 14 pound. This of use for brewers, dyers, and draining of ditches or low grounds, and watering of high grounds.

A small fire engine, forcing the water with one man's strength 80 foot high, for wetting the sails of ships, quenching fire in castles or great houses, or watering garden plots. The price thereof 30 pound.

An engine by which 2 men raise near 5 tun an hour 100 feet high. This is proper for the draining of mines or raising of great quantities of water, out of rivers or deep wells, to serve cities, towns and castles, for by greater engines of the same kind may be raised from 10 to 20 or 50 tun an hour, or any reasonable quantity of water any reasonable height, according as the force of river, horses or wind is applied to them. The price of this engine as it is now set up at Grocer's Hall is 60 pound, without the leaden pipes. If greater, the price will be greater. A Major Harsenet, Sir Samuel's agent, attended and exhibited the pumps daily.

1675. Patent to RICHARD HAYNES, Sullington, Essex. Cleaning a certain sort of grass seeds, properly called trefoyle seeds; and by some called *nonsuch*, and by others *hop clover*, from its husk and coarse grass, and which is much bettered and improved, and may be of great advantage to the nation. These cleaned seeds were sold in packets, with bills of directions, and the patentee said that "lands not worth ten groats per acre may be improved to 20 or 30 shillings an acre, by being sown therewith." It was sold at 4 pence a pound, and 12 pounds would sow an acre. This is granted for "14 years according to the statute."

Patent to SEVERAL TRULY LOYAL AND INDIGENT OFFICERS, for the profits of the Royal Oak Lottery, and all other lottery and lotteries whatsoever invented, or *to be* invented.

Patent to JOHN GEDDY and his partners, who are the inventors of Bee Houses and colonies to prevent swarming or destroying of the bees, and freeing the owners from much charge and trouble, and making the profit threefold more than in the usual manner.

These Bee Houses, by means of their form, prevent the bees from swarming, and induceth the bees to labour more than they would do in the old form of bee houses.

Bee keepers were invited to repair to Captain Hossington, Channel Row, Westminster, from whom both the bee houses and colonies might be had at a reasonable rate.

"Tumults about this time were raised by the London weavers, because some of their number used engines which dispatched in weaving the work of ten men, so that the others wanted work."

Patent to Mistriss REBECCA CROXTON, London. A new way of making Point de Venice, Point de Spain, and Point de France. Mrs. Croxton lived at Hammersmith, where she gave instructions in her art. "She also devised a very pretty way of washing these fabrics which was much better than the common one, and did not wear them out near so fast as formerly."

"At Faux Hall, Lambeth, were erected newly devised mills for the sawing, smoothing, and polishing of marble stones; and where all sorts of this kind of paving stones were sold at reasonable rates."

Sir Phineas Pett, son of Peter, formerly mentioned, built fifteen capital ships for the royal navy, besides many of lesser rates. Before this year (1675) all ships were built with *rising lines*, but the King's Fisher, Pett built with *horizontal lines*, and so contrived the port holes that most of her guns might point to one center, and thereby cause such breaches in the ship she fought with that could not be stopped with plugs; and that brought her safe off from being taken by 7 Algerine men of war. She outsailed the Golden Rose, a famous Algerine, and took her. Charles II., "who had very great skill in shipbuilding, observed that in his time the knowledge of the frigot way in which the Constant Warwick was built by Peter Pett, would be lost, for when she was repaired after the death of her inventor, she was spoiled in her sailing. He knew of no other ship built by the King Fisher lines except the Catherine yacht."

1676. Patent to MR. WHARTON and MR. STRODE, for an engine with leather pipes for quenching of fire, which carries a great quantity with a continual stream of water, with an extraordinary force, to the top of any house, into any room, passage, or alley, and is more useful than any hitherto invented,—attested under the hands of the Masters of St. Thomas's Hospital, and officers of the same parish, as having been experienced in the late great fire in Southwark.

Patent to JOHN BAILEY, for a new engine for deepening rivers and making them everywhere navigable, and taking away all obstructions and shelfs in a very short time. "Sir Martin Beckman, the chief Engineer of England, and the ingenious Sir Christo. Wren, Surveyor General, have given it their approbation, and also Charles II. was highly pleased after he had seen it in his presence take up about 1½ tun in little more than a minute, and was perfectly satisfied that it would answer, and that by means of its working horizontally it made no holes, but rather filled such as lay in the way of its working, and left the bottom of the river level as it wrought, whereby such inconveniences would be avoided as had happened from the common ballast lighters making such great holes in the river Thames, and which several of the king's, as well as merchant ships, coming to an anchor had broken their backs. And his majesty having been made acquainted that this engine having been sent below bridge to Berking shelf, where is nothing but hard shingle, and that after half an hour's breaking ground it took up, at 19 foot depth, about two tuns in a minute and a half during the whole time it was wrought, he said that he thought there was no way practicable for the deepening the bed of the river Thames and removing shelfs but by this engine." The engine was greatly improved by Joseph Cotinge.

Patent to WILLIAM CASTLE, and HENRY EWBANK, Esquires. Secure and commodious invention of iron fire hearths for ships.

Patent to WILLIAM SHERWIN. Invention for the printing of broad calicoes and Scotch cloth, with a double-necked rowling press, which is the only true way of the East India printing and staining of the said cloths.

This seems to have taken root, for in February, 1688, Sherwin informs all persons who understand printing calicoes, that they will find employment at his printing works in Well Yard, Bartholomew Close, London.

Watches.—Mr. Christian Huygens, of Zulichem, says he invented pendulum watches in 1657, and next year printed an account of them. Huygens caused several to be made in Holland. Then Mr. Fromantil, a Dutch clock maker, came over into England, and made the first clocks ever made here about 1662. One of the first made in England was presented by Seth, Bishop of Salisbury, to Gresham College.

" This sort of watch, and others, was made for several years with crown wheel pendulums, to play between two cycloidal cheeks. But a Mr. W. Smith afterwards made them go with a heavier ball, and to vibrate but a small compass. Hooke laid claim to this, and he showed a watch containing it to the Royal Society after the fire of London."

Huygens claims the circular pendulum, Hooke has the better title to it; " this pend does not vibrate backward and forward, but always round and round." The motion of Hooke's pendulum watches, so called from the regularity of their strokes and motion, is effected by the government of a small spiral spring running round the upper part of the verge of the balance. Hooke made one of these double balanced watches, which was presented to King Charles, and had an inscription—" R. Hook, inventor, 1658. T. Tompson, fecit, 1675." Tompson made two for the Dauphine.

" He had a patent drawn (though not sealed) in 1660, for these and other contrivances about watches, but that patent did not further proceed, on account of some disagreement about some articles in it with some noble persons who were concerned for the procuring of it. The same ingenious doctor had also a grant for a patent for this last way of spring watches in 1675, but he omitted the taking it out, as thinking it not worth the while. In 1662, Lord Kincardine carried two pendulum clocks to sea to discover the longitude, which succeeded."

Repeating Watches. — Clocks which, by the pulling of a string, strike the hour, quarter, or minute, at any time of the day, were a late invention of Mr. Barlow about 1676. About the latter end of King James the Second's reign, Mr. Barlow contrived to put his invention into pocket watches, and endeavoured with the Lord Chief Justice Allebone, and some others, to get a patent for it—and he set Mr. Tompson to work, who made a new watch according to his directions. Mr. Quare, a very ingenious watchmaker of London, had some years before been thinking of the same invention—but not being able to bring it to perfection, he laid it by until he heard of Barlow's patent. The watchmakers pressed him to hinder Barlow's patent; and applications were made at court. A watch of each invention was produced before the king and council; and the king on tryal was pleased to give the preference to Quare's watch, which circumstance was notified in the *Gazette*. The difference between the watches was this:—Barlow's repeated by pushing in two places on each side of the watch box, one of which repeated the hour—the other the quarter. Quare's repeated by a pin that stuck out near the pendant, which being thrust in, repeated both hour and quarter with the same thrust.

Many other contrivances made their appearance about the same time, all of which have disappeared.

1676. Printing of calicoes first set on foot in London.

1677. Patent to Dr. W. Jones, for the Elexir Proprietates, made with the volatile salt of tartar, which hath been prepared by the doctor in the presence of *ten* of the chief of the College of Physitians, and is sold at his laboratory, Old Spring Gardens.

The glass manufacture in some hands still of bad quality. Notice is given that "glass crizeled or decayed from the Glass House on the Savoy on the river's side, marked with a raven's head, which is an imperfect manufacture, will be taken back or exchanged, or the money returned for the crizeled."

Milled Lead.—The company formed under the patent built a lead mill at Deptford, for the supply of sheathing, scuppers, and all purposes relating to ships, houses, and other things wherein sheet lead is used. They made it "of all sorts and sizes, of length, breadth, and thickness, from 2 lb. to the foot square, to any thickness desired; any breadth to 3½ foot, and of any length to 30 foot long, or longer."

It was cheaper than cast lead, besides being lighter, more solid, or solid and smoother, all which adapted it better for all building purposes.

In the Forest of Deane and thereabouts iron was made of the cinders, being the rough and offal thrown by in the Roman and succeeding times, they having then only foot blasts to melt the iron stone, but now by the force of a great wheel that drives a pair of bellows 20 feet long, all that iron is extracted out of the cinders which could not be drawn from them by the foot blast. In this forest and as high as Worcester, immense quantities of these cinders, some in vast mounts above ground and under ground, will supply iron works for some hundreds of years. The prime and best iron is made from these cinders, and is of a most gentle, soft, pliable nature, works easily and quickly. A smith will give 20 pounds a ton for it for scythes and sickles. Spanish iron works churlish and dogged. The greatest part of *sow iron* is sent up the Severn to the forges into Worcester and Stafford, where it is wrought into small commodities and diffused all over the kingdom.

The iron works on the Slane in Wexford and Wicklow, which were set on foot some years before this by Sir J. Cutler and others, were now in the hands of Sir Robert Clayton, but were working at a loss and borrowing money to go on. It was proposed to make the Slane navigable to get at the woods on its banks for fuel.

Most of the iron works in Surrey and Sussex were extinct from lack of wood. "Many," says a contemporary, "think there should be no iron works any where, as they devour the woods, but they are more to the public advantage than the woollen trade, and *now* employ as many people."

"Wind saw mill erected on the Bankside over against the Savoy, and it is so made that the whole turns round."

The advocates for the improvement of the linen manufacture, as an inducement to farmers to sow flax, stated that 1 acre of middling land properly worked will raise 3 cwt. of flax, well dressed and made fine; this will make 400 ells of cloth, that will sell at 3 shillings an ell, and bring in 60 pounds to the weaver.

The Flemish and French linen fabrics were brought to great perfection; the importation of French canvas, lockram and coarse cloth had almost driven the manufacture of these fabrics from England. Twine and yarn had been made extensively in Suffolk, but since their importation from Eastland ports, that trade was nigh lost. In Kidderminster formerly 100 pounds a week were spent in linen yarn, (made in Kent and Suffolk,) and used in their lynsey woolseys, besides large quantities in Manchester also. Now that was mostly had from Germany. About 1630 there was a great trade in linen cloth in Lancashire and about Cheshire; now that was beaten down by the better and cheaper German cloths. Bed ticking was also brought in so cheap from Flanders that it had stifled the manufacture in Dorset and Somerset. Two years after this the English manufactures exported to France amounted to £171,000, while the French imports into England exceeded £1,102,000, of which £462,000 was for lockram, canvas, and dowlas. Frippery and salt made the greater part of the balance.

3,000 acres of land near Stratford-on-Avon, belonging to the Earl of Middlesex, were let for £3,120 a year. At this time lands in England were worth from 14½ to 16 years' purchase; in Scotland from 20 to 21 years' purchase; at a distance of 3 hours' sail on the other side, in the north of Ireland, fat land was worth 8 years' purchase only. England was the richest and most populous of the three countries, and Scotland the poorest and thinnest peopled.

1678. It is ordered that all dresses for the dead shall be made of sheep's wool under a penalty of £5. The rich disliking wool, paid the forfeit andused linen. The poor felt it a grievance that their poverty should prevent them burying in linen also.

Widow AMY POTTER presented to Charles II. decent and fashionable shifts, and dressings for the dead all of woollen, and was the first that put the making such things into practice; and his Majesty well liking the same, inserted an advertisement in the *London Gazette*, to make it known that widow Potter wholly applied herself in making both lace and plain of all sorts at reasonable rates.

Three months afterwards, in order to encrease the woollen manufacture, and to encourage obedience to the recent act for burying in woollen, the king granted a patent to "widow Potter for the sole excercise and benefit of making all sorts of woollen laces for the decent burying of the dead or otherwise, she being the first inventor thereof."

"Mrs. Potter," says Taylor, "lived at the Woolpack, in the Strand, and not only made comfortable things for the dead, but by doing so she made a very good thing for herself, and became a person of substance and worship."

1679. Patent to EUSTACE BARNABY. Sole use and art of planting safflower, which he hath acquired by great pains and trouble in Germany. He gave a licence with directions for cultivation, and seed to sow an acre, for 25 shillings; the seed to sow at half the profit.

1680. "Man," says Defoe, "is the worst of all God's creatures to shift for himself. No other animal is ever starved to death. Nature has provided them both food and cloaths, and placed an instinct that never fails to direct them to proper means for a supply; but man must either work or starve, slave or die, and if he is without three things—money, friends, and health—he dies in a ditch, or in some worse place, an hospital. Ten thousand ways there are to bring a man to this, and but very few to bring him out again. Some who want courage to bear what they see before them, hang themselves for fear; others break the bounds of laws to satisfy nature, and turn open thieves, housebreakers, and highwaymen, till they run the length of the gallows. Others, being masters, or more cunning than their neighbours, turn their thoughts to private methods of trick and cheat, a modern way of thieving, every jot as criminal, and in some degree worse than the other, by which honest men are gulled to part with their money, and then left to take their course. Others, yet urged by the same necessity, turn their thoughts to honest invention, founded upon the platform of ingenuity and integrity. These two last sorts are what we call PROJECTORS, and as there are always more geese than swans, the greater denominates the less, who, like cuckolds, bear the reproach of other people's crimes. A mere projector is therefore a contemptible thing, driven by his own desperate fortune to such streight, that he must be delivered by a miracle, or starve; and when he has beat his brains for some such miracle in vain, he paints up some bauble or other, as players make puppets talk big, to show like a new invention, gets a patent for it, divides it into shares, and as they must be sold, funds are raised to carry it on by men who have more money than brains. When the inventors have carried on the jest till they have sold all their own interest, they leave the cloud to vanish of itself, and the poor purchasers to quarrel with one another and go to law about settlements, transferrings, and some bone or other thrown among them by the subtlety of the author to lay the blame on themselves,—then good night patent and invention,—the projector has done *his* business. As a general rule of caution to those who would not be tricked out of their money by *engineers*, *patentees*, *committees* and *pretenders to new inventions*, let them observe, that *all* such people who may be suspected of *design* have assuredly this in their proposal, YOUR MONEY TO THE AUTHOR MUST GO BEFORE THE EXPERIMENT. But the HONEST PROJECTOR is he who having by fair and plain principles of sense, honesty, and ingenuity, brought any contrivance to a suitable perfection, makes out what he pretends to, picks nobody's pocket, puts his project in execution, and contents himself with the real produce as the profit of his invention." Although projects were in abundance before this date, Defoe places the *projecting humour* no farther back than 1680, dating its birth as a monster about this time. Prince Rupert, cousin to Charles II., gave great encouragement to that part of it that regarded engines, and Bishop Wilkins, in Defoe's opinion, added as much of the theory to it as writing a book could do. The prince himself was a projector of no mean merit, and left a *metal* called by his name; but the method of making it died with him, to the great loss of the undertaker, who with no small charge erected a water mill at Hackney, known as the Temple Mill. Guns made of this metal had a reddish colour, different from brass or copper. He also invented *a floating machine*, to be wrought with horses, for the *towing* of great ships both against wind and tide, and another for the *raising of ballast*, which as unperforming engines were made, exposed, tried, and laid by, before the prince died. Prince Rupert also invented mezzotint engraving.

Patent to ROBERT PASK, at the Inkbottle, Royal Exchange,—a very choice sort of *black* ink in *hard balls*, with that conveniency that you may wear them about you without any damage to the ink or to your linen; cut a little of it into a spoon, with fair water, or any wine except red, and it will be immediately fit to write with. It is brought to that goodness that it is fit for records. The longer you keep it in ball, in liquid, or in writing, the better it grows. Its price is six pence a ball.

Patent to MR. THOMAS WARREN, apothecary in ordinary to his majesty. After many years' trial and with great industry and cost he hath found out a most curious and excellent way of preserving dead bodies from putrefaction, change of colour, or complexion, without disbowelling, searclothing, mangling or cutting any part thereof, to the great approbation of several of his majesty's physicians and others of the college; and having presented an experiment to his majesty of a body so preserved, his majesty was very much satisfied therewith. That so useful an invention may prove generally serviceable, for £5 he will secure any dead body above ground for several years.

Strasburgh onions: a good trade was carried on in this article, but the seals of the city were counterfeited, and put on old seed, and seed from other places. The genuine was sent to the well-known Daniel Demetrius, from whom only it was to be had.

1681. A while before this, many persons under great names had formed public companies with *joint stocks*, which "begot a *new trade* which we call by a new name, STOCK JOBBING, which was at first only the simple transferring of interest and shares from one to another, as persons who alienated their estates; but by the industry of the exchange brokers, who got the business into their hands, it became a trade, (about this time,) and one perhaps managed with the greatest intrigue, artifice and trick that ever any thing that appeared with a face of honesty could be handled with; for while the brokers held the box they made the whole exchange the gamesters, and raised and lowered the prices of stocks as they pleased, and always had both buyers and sellers, who stood ready innocently to commit their money to the mercy of their mercenary tongues. This upstart of a trade having tasted the sweetness of success which generally attends a *novel proposal*, introduces it as a proper engine to find work for the brokers. Thus stock jobbing nursed PROJECTING, and projecting in return has very diligently pimped for its foster parent till both are arrived to be public grievances, and are now indeed almost grown scandalous." One would imagine this had been written yesterday instead of 160 years ago.

In a letter from Mr. Savile to secretary Jenkins, he says "that M. Bonhomme, a linen draper of Paris, was about to emigrate with all his family to England, and will be able to give you some lights into the method of bringing the manufacture of sailcloth into England."

"Birch wine rightly prepared and made of the sap of birch trees, by experience known to be a wholesome and pleasant drink, having the colour and flavour of Rhenish wine," was first sold by Mr. Garraway at his Coffee House, Exchange Alley.

SIR ROBERT TALBOT, "the infallible medicine for the cure of agues and fevers; the price, a guinea for two doses."

Patent to MR. WILLIAM PAWLEY and MR. EDWARD DALLOW, "an engine for draining of fenn grounds, and all sorts of pits or mines of any depths, and flowing of lands, is now perfected." The engine was exhibited by Dallow at his glasshouse in East Smithfield, and some were erected.

Sir Sam. Morland. This evening (July 30) the King, Queen, and Prince of Orange, being attended by divers foreign ambassadors and other persons of eminent quality, and not a few of the English nobility, together with a numerous train of near 1,000 persons returning from the park, Sir Samuel Morland, with the strength of eight men, forced the water (mingled with a vessel of red wine to make it more visible) in a continued stream, at the rate of about 60 barrels in an hour, from the engine below at the park pale up to the top of the castle, and from thence into the air about 60 foot high, to the great admiration of their majesties and all the beholders, as well foreigners as others, who unanimously concluded that this was the boldest and most extraordinary experiment that has ever been performed by water in any part of the world. On Monday morning the king and prince saw the same engine, wrought only by two men, force the water from below through the leaden pipe in a full stream above the top of the castle.

This day (Aug. 14) his majesty having sent for Sir Samuel Morland into his bedchamber, (when were present his royal highness Prince Rupert, the lord chancellor, the lord chamberlain, and divers other great ministers of state and members of the most honourable Privy Council,) was graciously pleased to declare that he was highly gratified with all the late experiments and extraordinary effects of Sir Samuel's new water engine, and therefore as an earnest of his particular grace and favour gave him with his own royal hand, and commanded him to wear it on his breast as a mark of honour during his life, a fair medal of gold, fastened to a green ribbon, on one side of which was his majesty's effigies, and set with diamonds of considerable value, and on the other side was a Latin inscription. After which the lord chamberlain by his majesty's order caused him to be sworn Master of Mechanics, and the inscription on the medal to be registered.

1682. Patent to John Cooke, of Fawler, in Oxfordshire, a spring snaffle that commandeth with the greatest ease imaginable all hard mouthed runaway horses, stumbling or starting horses, and those that ride heavy in hand, and is useful for running, hunting, or travel. Sold at the White Lion, near the Exchange.

William Morgan, cosmographer to his majesty, "Map of an exact survey of London, Westminster, and Southwark." His majesty having expressed his gracious approbation thereof, granted his royal warrant that no person, on any pretence whatsoever, should presume to copy or epitomise the same for the space of 14 years.

Henry Holden, compounding and mixing metals without any noxious ingredients for making of all sorts of glasses. The king made him his servant in ordinary, and gave him authority to put his imperial arms on all glasses made by his order.

Patent to the Honourable **Robert Fitzgerald** and others, who had found out the art and mystery of reducing the salt water of the sea into good, perfect and wholesome fresh water, in quantities sufficient to serve all the uses of any ship at sea; and that this secret was to be performed without mixing any unwholesome ingredient at all, whereby to endanger the lives or health of any person that should make use of it. The king commanded the Right Honourable Robert Boyle to attend him, who upon due consideration so fully satisfied his majesty of the wholesomeness and usefulness of the said water, he, willing to encourage so useful an undertaking, gave Mr. Fitzgerald and his partners a patent grant of the profits of the same.

"This invention made what was called a great sensation on the public. A variety of books were published for and against it, and it was the subject of more than one long poem."

"His majesty finding that the water prepared from sea water was as fresh as any about town, he would have the water made use of in all maritime garrisons when or where fresh water was not to be had. To prove its virtue Mr. Boyle attended his majesty with a certain prepared liquid that would show as much as $\frac{1}{1000}$th part of salt in water, and none could be discovered in the sweetened water."

1683. The penny post introduced into London by one Murray on his own account. He resigned his scheme to Mr. Dockwra, who appears to have improved its details so much as to be entitled to the praise of its inventor. Being considered an encroachment on the Post Office, he was deprived of it by Government; "Mr. Dockwra had the honour, however, to have the injury done him repaired in some measure by the public justice of Parliament. 'Twas no question a great hardship for a man to be master of so fine a thought that had both the essential ends of a project in it—*public good* and *private advantage*,—and that the public should reap the benefit and the author be left out; but he had the satisfaction to see the former injury disowned, and an honourable return made even by them who did not the injury, in bare respect to his ingenuity."

Fine hats now sent to Holland, glass clocks, watches, fringes, gloves, coarse paper, canvas, (sailcloth?) saffron, soap, and woollen yarn.

Patent to **Richard Maundrel** and **John Williams**, the sole casting and making hollow pewter or block tin buttons, of which they are the first inventors,—for 14 years.

"King, the driver of the Northampton coach, was taken as a notorious highwayman; his coat is described as made of 'blew perpetuana, with fashionable alcomia buttons.'"

Patent to Sir William Jennings, for all baths and bagnios. "A mineral bath," says Sir William, "is set up in Long Acre, and a spaw for mineral waters to drink, concerning the virtues of which a book is now published by Dr. Haworth; and his majesty and the prince have been to see these baths." "At the desire of several ladies and persons of quality, Saturday was allotted to them to come to sweat and wash in the Royal Bagnio; another day is now added for their services, which is Wednesday." "Rubbers and barbers who attend gentlemen are very troublesome, by demanding a reward for their attendance; five shillings and sixpence is the whole charge," says Sir William.

1684. Warren, the embalmer, transferred his invention to William Russel, a coffin maker, who notifies that "he has the art of preserving dead bodies without emboweling, and that he has coffins ready made and preserves the body for £5.' Russel says he was employed by the Earl of Carlisle to fetch over the body of the lamented Frederic Howard, Esq., who was slain in the siege of Luxemburg. "He performed the same to his Lordship's satisfaction, having taken up the body after it had been buried for three months, and so well preserved it that he brought it over in a coffin he had purposely prepared to his house in Fleet Street, where it lay in state, and was buried last month (October) in Westminster Abbey."

Patent to Richard Haynes and partners, for improving cyder, and the juice of gooseberries and currants, &c. The patentees exposed their invention and manner in print, whereby they showed how simple cyder, frequently sold for 30*s*., may be made as strong, wholesome, and pleasing as French wines, without adding any thing to it but what is of the juice of apples; and how to raise apple trees, gooseberries, &c., beyond what hath been heretofore made known.

Patent to Peter Whalley, gent., a certain engine or pump lately invented by him, it being much more useful to all purposes than any hitherto known or used.

"Charles II. orders that the instruments to sweeten sea water shall be provided for his ships and garrisons where they have not naturally good water. He had received a letter from Captain Macdonnel from on board of the Greyhound frigate near the coast of Spain, wherein he affirms that he kept of the patentee's water some that was given him in his ship's hold from his leaving England, being four months, and then having several officers on board of him, gave them a taste of it, pretending it to be of the spring near Sally, where he had watered, and which is as good as the best in the Straits, and they drank of it as such till he discovered what it was, and then they approved of it to be as good as could be drank."

Certificates from Trinity House, captains, shipwrights and merchants, all approving of its use. Its value seemed to encrease, for in January, 1685, the king, a fortnight before his death, "was pleased to send to the lord mayor, closed in a silver box, sealed with his majesty's seal, the *receits of the several cements* used by the patentees for making sea water fresh, as also the *receit of their metalline composition* and ingredients, certified under the hand of the Right Honorable Mr. Boyle, to be kept so sealed up by the present and succeeding lord mayors, lest a secret of so great importance to the public might come to be lost if lodged only in the knowledge of the few." This box and its contents must be still in existence, among the "curiosities" of the Mansion House[a].

Patent to ALEXANDER BROWN, "who having caused to be wrought above 100 prints in mazatinto, after Sir Anthony Vandyke and others, is to have sole printing and publishing the same for 14 years."

PLAYING CARDS.—"To encourage the manufacture of English made cards, and to prevent importation of foreign cards, an office was erected in Silver Street, Bloomsbury. The price was put on each pack, to the end that none under any pretence may sell them at a dearer rate. The very best cards sold in London are had at 4 pence per pack."

"His majesty being well satisfied with the performance of Mr. Grinling Gibbons in the making his majesty's statue lately set up in the Royal Exchange, hath been pleased to forbid all persons to copy the same in graving, etching, or mazatinto, without the approbation of the said Gibbons."

Firelocks now have cocks and hammers reversed, in the manner of a wheel-lock.

Patent to LEONARD BOSWELL, Esq. Certain engines for the more speedy and commodious way of making cyder and perry. They were made by Henry Allen, to whom the patent is assigned, and who likewise made "curious engines for raising water and draining ponds."

1685. The ships employed in the coal and coasting trade were at this time generally foreign built. To stop a practice so much at variance with the Navigation Act, a duty of 5 pounds a ton was laid on foreign built craft.

Patent to JOHN BELLINGHAM, Esq., for making square window glasses for sashes and coaches, excelling the Normandy for strength and clearness. A 24 inch glass was charged 12 shillings.

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[a] "In 1686 the doctors of the College of Physicians gave it under their hand that sea water made fresh was undoubtedly good against scurvies and other diseases, and directed its use in diet drinks, coffee, chocolate, and tea, *instead* of *fountain water*.

"In 1687 his majesty, James II., was fully satisfied with the report of the whole garrison at Tilbury, which with one engine not exceeding 6 foot in diameter, made 600 gallons in 24 hours, and was supplied with fresh and wholesome water."

Patent to NATHAN SOMERS and LAWRENCE CRABB, for grinding logwood, and all other woods for dying, to a fit degree of smallness for the use of dyers, without any moisture in the work, the ground woods retaining their full tincture, and keeping without wasting in weight.

Patent to JAMES DELABADIE. An engine for beautifying of cloth, serges, cottons, bayes, and all woollen manufactory, by napping or freezing the same without honey, molloses or any moisture, whereby the goods are greatly improved and preserved from moulding, though never so long kept, it being a different manner (and which renders them much more beautiful for sale) than any formerly used.

The engines were sold, and goods were taken in to be finished according to the patent process. *Old clothes* were by the same means made like new.

1685. Before this the butchers in London sold their bullock hides to the fellmongers with the tails on. The French refugees bought them up, and introduced the manufacture and use of that exquisite production, *ox-tail soup.*

1686. JOHN FINCH, JOHN NEWCOMB, and JAMES BUTLER, sole making of a woven wyre engine invented by them, most commodious for all bakers, millers, mealmen, druggists, glassmen, and others; and far more profitable, expeditious and easy, than all other bolters heretofore used. They were exhibited in use at J. Newcomb's house in Aldersgate Street.

MILLED LEAD.—The manufacture of milled lead used for buildings, and sheathing ships against the worm, which for sometime hath been neglected, on pretence of its extraordinary eating and decaying the rudder irons, is now again set on foot; and printed papers are published, say the patentees, fully answering all objections that have been raised to hinder its public use. The lead was much used by maulsters to cover their kilns instead of hair cloth, the mault being better dried, and totally defended from the smoke which issues from the cloth, and gave an ungrateful taste to the liquor.

PATENT OPPOSED.—Upon a full hearing before his majesty in council, on the 12th May last, between the Lord Viscount Grandison and Henry Howard, Esq., and Samuel Hutchinson, touching a new invention for smelting lead oar, for the exercise whereof each side hath obtained letters patent, his majesty was pleased to declare, that the patent of Samuel Hutchinson should be made void—and accordingly, pursuant to a proviso in the said patent, it was made void.

Patent to EDWARD COOPER, Bedford Street, for sole printing and publishing the effigies, draughts and portraitures, which he hath already done or shall hereafter do in mezzotinto for 14 years.

Patent to JOHN CHATER. New art of making, marbleing, veining and finishing of mantel pieces for chimneys. They were sold at reasonable rates, at his house, Gutter Lane, London.

License to RICHARD RANDALPH, to print his map and book of the Present state of the Morea, with prohibition to all others for the space of two years.

Patent to Colonel JOHN LEGGE and two others, office for the sole registering the names, and drawing the covenants, of all persons going as emigrant servants to the plantations.

1687. Sir ROBERT CLERKE, Knt., ROBERT BRENT, and TALBOT CLERKE, Esq. New invented furnaces, vessels, ways and means, &c., for extracting all metalline bodies out of their respective oars and minerals, and separating all mixed metals each pure from the other, particularly gold and silver from all inferior metals.

The patentees erected works, and "they are considered to have revived the art of refining copper, which had been disused in England since the Saxon times."

William Phipps, an American, the son of a blacksmith, and who was brought up as a ship carpenter, received a ship from Charles II., in order to search for and unload a rich Spanish ship that had been sunk on the coast of Hispaniola. He returned unsuccessful, and in great poverty. He failed in getting another vessel from James II., but he prevailed on the Duke of Albemarle to join him, and advance a sum for the necessary preparation. Phipps then collected the remainder, engaging to share the profit according to the twenty shares into which he divided the speculation. He sailed in 1687, in a ship of 200 tons burden. When he was on the eve of abandoning his adventure for the second time, he was so fortunate as to bring up so much gold that he returned to England with £200,000. Of this he got £20,000 himself, and the Duke got £90,000. "The king was advised to seize both the ship and cargo, under a pretence that Phipps had not given him accurate information when he applied for his majesty's patent. But the king answered with much greatness of mind, that he knew Phipps to be an honest man, and that he and his friends should share the whole among them, had he returned with double the value; and his majesty conferred the honor of knighthood on him." "'Twas a mere project—a lottery of a hundred thousand to one odds, which, if it had failed, every body would have been ashamed to have owned themselves concerned in; a voyage that would have been as much ridiculed as Don Quixot's adventure upon the windmill. Bless us! that folks should go three thousand miles to angle in the open sea for pieces of eight lost forty years before. Why they would have made ballads of it, and the merchants would have said of every unlucky adventure, 'twas like Phipps' wreck voyage; but it had success, and who reflects upon the inventor?" Sir William's good fortune sanctified for a generation the most extravagant expectations from crowds of absurd projects, and which did not reach their crisis until the bubble year, 1720. Phipps was afterwards high sheriff of New England, and is the ancestor of the present Marquis of Normanby.

The governor and company of WHITE PAPER MAKERS, who had a patent, represented to the king, that persons daily bought up, in large quantities, white linen rags, gloves, clippings, parchment shreds, calves pates, and water pieces, and other materials for making white paper, and exported them. His majesty prohibited their exportation.

Patent to Mr. JOSEPH MASON, Norwich. An engine which saves all weavers the trouble and charge of a *draft boy*. This invention is the first on record of a class of contrivances which have infinitely improved the art of weaving. The first step was considered to have been made 80 years after this date.

1688. A company formed, with the Earl of Argyle at its head, to raise the treasure ship called the Florida, that was blown up by Smallet, of Dunbarton, and sunk off the Isle of Mull, at the time of the Spanish Armada. The divers descended 60 feet under water, and brought up gold chains, money, and other articles, but in such small quantities that they did not pay the cost of getting them. Phipps had engrossed all the favours of good fortune that were to be disposed of, and Lord Mordaunt, Sir John Narborough and others were wholly unsuccessful in their wreck fishing projects.

Patent to CHARLES HOLMAN. Certain white powder which, being dissolved in water, beer, ale or wine, doth presently turn the same into very good writing ink, for the general conveniency, especially those in the country and at sea.

Jersey gunpowder was the choice sort at this period. Mr. Pain, who made the finest shining white powder in Jersey, removed to the Temple Mill, Bow, near London, and introduced the improved manufacture.

ANTHONY GERENTE, or DE CLAIRANTE, Esq., and PETER VANDENAUKER, merchant. New invention of three sorts of tar; the first for saving the charge of sheathing ships, by preserving them from the worm; second, keeping ropes in the water or in the air; third, for resisting fire, and melts not in the sun.

A few years after this there appears in the market the famous "oil of English pitch," to be had at one shilling the bottle, sealed.

Sir JOHN PARSONS, SAMUEL VINCENT, Dr. NICHOLAS BARBON, and partners. To insure houses, &c., from fire; prohibits other companies which had begun to effect insurances on this scheme.

1689. To a relation of the Rev. Mr. George Walker, late Governor of Londonderry, the king grants a license for the sole engraving and publishing Walker's effigies, and forbids any other person presuming to print or publish the warlike man of God's portrait.

Number of houses in England and Wales stated at 1,230,000.

1690. Patent to JOHN LOFTINGH, merchant, London, for an engine not heretofore used in their majesties' dominions, for the more readily extinguishing of fire. An experiment with one of the machines was made before their majesties, at Kensington House, and received their royal approbation.

Sword Blade Company say, that great industry has been used for erecting a manufactory of sword blades at Newcastle, by several able working men brought from Germany, which being now brought to perfection, the undertakers have thought fit to settle a warehouse in New Street, London, where cutlers may be furnished with hollow sword blades at reasonable rates. They soon afterwards sold their patent and plant to some London merchants, and with the money purchased lands in Ireland worth £20,000 a year. The Irish parliament resisted the company on public grounds, and compelled them to sell their lands. The corporation was virtually dissolved, but its name survived until the bubble year, 1720, when it finally disappeared.

Previous to this, contracts for ships ran for "English oak and plank." "English" now left out—the wood is so scarce as not to be had.

1691. WILLIAM WILKINS, who has been employed in taking up the bodies of several persons of quality in Ireland, after they had been about 10 months buried, and bringing them sweet and entire to England, which he performed very much to the satisfaction of those who employed him, is removed from Charing Cross to the sign of the Coffin, over against York Buildings, in the Strand, July 23, 1691.

1692. Fine and cheap hats had been for a long time made at Havre and some other parts in Normandy, and imported in large quantities into England. English hats are now so greatly improved that foreign hats are no longer to be imported.

The finest sort of plate glass usedfor coaches and mirrors had also till now been imported, but English glass is at length superior both to the French and Venetian for these purposes.

Invention of MOULD CANDLES. Many tallow chandlers in and about the cities of London and Westminster, according to Anthony Redhead, use moulds of mixt metals for making of new fashioned candles—these moulds are to make 3, 4, 5, and 6 in the pound, and also flambeau fashion. Moulds may be had from him at his shop in Fenchurch Street.

Patentees and undertakers for improvement of the glass manufacture in England, now say, that all sorts of exquisite looking-glass plates, coach glasses, sash and other lustrous, for windows, far exceeding those of Normandy, may now be had at their warehouse. A branch of the Vauxhall Company.

Patent to JOHN TATHAM, for brewing and distilling all sorts of liquors and spirits at far less charge than usually done. Tatham erected a distillery at Nine Elms and at Limehouse. His invention was pirated.

Patent to WILLIAM SUTTON, for ordering all sorts of linen and woollen cloths, and other manufactures thereof, and all silks, stuffs, hats, and leather, so as to make them hold out water, and for preserving woollen manufactures and hats from mildew. Sutton had an office in Drury Lane for receiving goods to be waterproofed, and he had a manufactory in Wales.

Patent to JOHN GREEN. A coach, which for ease, safety of riding therein, turning in narrow passages, ease of horse draft, and other conveniences, exceeds any now in use. He made and sold them.

Patent to Mr. EDWARD HURD, for lacquering upon iron and other metals useful for ornament, and preservation from rust.

Guns, pistols, sword blades, and other iron to be lacquered, were to be sent to the Japan Warehouse, Royal Exchange, or Japan House in Hoxton, where the art was carried on.

Chartered Lustring Company had sole privilege of making this fabric in England, and under their patent the manufacture was brought to great perfection. They introduced many improvements, both into the weaving machinery and into the dying and dressing of the silk cloth.

Patent to JOHN LOFTINGH, for an engine for starting of beer or other liquors, which will deliver from 20 to 30 barrels an hour; completely fixed with brass joints at very reasonable rates. A publican's bar-pump.

The patentees of an engine called the Sea Crabb, concerned in the recovery of guns out of the wreck of the Loyal London, formerly blown up in Lee Road, notify that they have laid a red buoy over the wreck, with a tin vane, with a broad arrow-head; not to remove same.

An act prohibiting the introduction of hair buttons, recites that, in the reign of Charles II., the importation of foreign bone, lace, cut work, embroidery, fringe, bond strings, buttons, and needle-work, and all foreign buttons made of thread or silk, was prohibited; since that period hair buttons are chiefly worn and used; and that the button makers of England do make better hair buttons than any imported from foreign parts—yet, because they are not named in the King Charles' act, great quantities are imported by enemies to the manufactures of this kingdom, and the native button trade of England is very much decayed. Foreign hair buttons are therefore prohibited.

1693. Patent to JAMES TREFUSIS, JOSEPH WILLIAMS, JOHN and NICHOLAS HONEYCHURCH, for an engine to enable a person to walk under water, which engine hath several times been tried between Chelsea and London Bridge, and at Limehouse Reach, where the inventor was six hours at a time under water without any want of air, to the great satisfaction of many persons then present. Two of which engines are now sent to work upon one of their majestys' ships.

Some persons who imitated and counterfeited the engine, are warned not to proceed. Joseph Williams was the inventor.

Mr. JOHN OVERING says, that "some persons have taken on them to sell shares in the engine that was lately tried in the Thames with great approbation, when a person walked therein under water from above Whitehall Stairs until he came below Somerset House, though they are neither the authors of nor interested in the said engine. I am the true and real inventor of this engine."

1693. Patent to "Captain THOMAS PHILLIPS, second engineer of England," for a method of casting guns in moulds of metal that would last many years.

This patent was granted after exhibition of a model before the Lords of the Privy Council.

A company incorporated for smelting down, purifying, and refining lead ore with pitcoal and seacoale; and persons having ores to dispose of are invited to repair to the cupola, near Bristol, or Governor and Company, Sadler's Hall, near Cheapside.

Patent to THOMAS HOLLAND, for an engine for drawing, forcing, and discharging water, in shorter time and in greater quantities than heretofore, out of drowned mines and coal pits; useful also for drains, and supplying pipes and conduits with water, and for pumps for ships and houses.

One of these engines, erected at the long deserted mines of Row Pits, in the Forest of Mendip, in Somerset, discharges above 50 tuns an hour, at 100 feet depth, wrought only by two horses; the pump, by a proportional strength of men, will lift a 100 tuns or more in the same time at 20 or 30 feet depth.

PAPER HANGINGS. "*Japan hangings*, of various colours and figures, 12 yards long ½ ell broad, are sold for 3 shillings. Screens, landscapes, chimney pieces, Cæsar's heads, etcet."

IMITATION OF TAPESTRY. "The gentlemen concerned in the patent for the imitation of Tapestry, give notice that they attend at Outroper's Office, where are daily sold those pleasant hangings, done upon cloth, (not paper,) consisting of various Indian figures, history, landscapes, of any dimensions required, to answer occasions between and under windows, etc. History and landskip, 12*d.* per ell, Flemish; Indian figures, 14 pence per ell, Flem."

"The Patentees of the Blew Paper warehouse sell all sorts of Japan and Indian figured hangings. Another sort of large Japan and forest work in pieces of proper size, after the new mode of real Tapestry. Another sort in imitation of wainscot, accommodated for rooms, with great variety of screens, chimney pieces, sashes, and other things of curious figures."

Patent to Captain JOHN POYNTZ, for a new engine for deepening havens or barred places, channels, and to drain mines and overflowed lands.

Patent to THOMAS WINTER, for certain engines for grinding and sawing. Like a great number of other patents at this period, this was made a joint stock company, and consisted of 40 shares. Winter complained that several of them were not called for by their owners.

SHINING JAPAN INK, made by Thomas Harbin, in the Strand, was started as a rival article to Holman's "England's Record Ink," which had become a great favourite with the public and most profitable to its compounder.

The "Japan Ink," and the "Record Ink," and "Anderson's Pills," were among the first systematically puffed and advertised "manufactures" in England. 40 years after this period, it was said that upwards of £35,000 had been spent in this way by the rival inkmakers, and still with good profits remaining.

Harbin had, like Holman, a "Japan Ink Cake" and a "Japan Ink Powder" also. Holman changed the name of his pen fluid to "Holman's London Ink." "Harbin was therefore the greater mercantile genius of the two, for 'Shining Japan Ink' is a name chosen to convey an idea of ink of superlative quality even in these times of refinement."

GERMAN BALLS, of excellent use for preserving and beautifying all sorts of black leather, that no manner of wet can penetrate or damage it, especially boots, shoes, and coaches, making them look as if they were almost new.

"Captain EDWARD CUSTISS announces that he hath joined himself, with his maritime engines, to the company interested in a peculiar diving engine, distinct from all others, known by the name of Donnils and Holinshed's, wherewith they undertake to take up guns, merchandise, treasure, etc., and to blow up or break to pieces ships in any competent depth, and then to take up the lading.

"Proprietors of wrecks, recoverable by this art, or discoverers of old wrecks, are requested to seek encouragement from the company."

Grant to the Duke of Leinster, for 20 years, of all wrecks, from 12 degrees south to 40 degrees north; and his Grace invites all persons interested in such wrecks to apply to his agent, Samuel Briggs.

STREET LAMPS occasioned much trade hostility at this period. The differences, however, between the opposed patentees of the "lucidaries" and "new lights" being "made up in a friendly way, persons were at liberty to adopt the lamps of either without fearing violence [a]. Persons paying to the patentees of any lamps which were "distanced by two justices of the peace," were exempted from hanging out a lanthorn and candle before their houses after sunset.

1694. Patent to JOHN TIZACK, merchant, for a night engine, which being set in a convenient place of any house prevents thieves breaking in and surprising the inhabitants, whereby many robberies will be prevented.

Patent to Sir JOSEPH HEARNE, and others, for making and coining copper farthings.

Patent to R. WATSON (?) for a lifting engine, "which raises with great ease and in a short time the greatest weights to the top of the highest buildings. Such as have reason to use said engines in wharfs, on shipboard for weighing anchors, careening of ships, setting of masts, lifting of heavy stones out of mines and quarries, may be supplied with them in Boswell Court."

1695. Honourable PHILLIP BERTIE, ROBERT SHEFFIELD, Esq., and Mr. JOHN

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[a] "The magistrates, say the lamp makers, (1691,) have adopted the intervals at which lights should be set up, and the inhabitants ought to apply to the patentees of lucidaries, or subscribe to their proposal. Many of the lucidaries set up in Spitalfields were broken and carried away.

Several tinmen and others having been employed by the patentees for the "new lights," and thereby having attained the skill of making cases, furnished persons with the new lights in prejudice to the patentees, who have expended great sums in making and perfecting this useful invention. The tinmen, in 1692, eventually quitted all their pretences to lighting the streets, and resigned up all their lamps. A new sort of lamp, called the "lights royal," was brought out in 1693. The inventors, pursuant to the orders of the Lord Mayor, set up some of these lights on the Exchange and in Cornhill, when several of them were shot at with bullets, and a person standing near had like to have been killed. Whether the dislike was to the lamps as lights, or to them as being different from the "lucidaries" and "new lights," has not been decided, as the shooters could not be discovered. They cast out a powerful and extensive light, so as to make men passing about their affairs in the night not only tolerable, but pleasant. They were offered to the trustees of the lighthouses, who told the patentees they were as expensive as the lamps in use, and that a new invention should save candles. The patentees replied, they thought the saving of mens' lives and goods, by a better light, of more importance.

The *conic lamps*, for lighting the houses and streets of towns, were invented and made patent in 1706; with the "lights royal" and "lucidaries" they became disliked at the fashionable end of London, and in 1707 a great number of them were broken in Hyde Park, by those who, from their wanton acts, showed they loved to walk in darkness rather than in the light.

HAWKSBEE's new invented engine, which pulls all sorts of stuffs by hand or man's labour, and may be wrought at all seasons. "Machines might be had, and finished carpets, druggets, stuffs, stockings, dyed cloth, and stuffs, quilts, and hangings, were scoured and fulled with expedition, and at reasonable rates, at John Hawksbee's, All-hallows Lane." The invention was Bertie's.

Patent to WILL. YOUNG for new invented whips. "The stocks are of the best *Greenland whalebone*, and most curiously fitted up. Are much better than ever were yet made, and much cheaper. The patentees intend to keep the next Easter fair."

Patent to ABRAHAM KEMP, for making orchal not any way inferior to that marked F, attested by silke dyers; makes blue cake orchal, which the French use, and *blue* liquid orchal for Scotland.

WILLIAM WALCOT, Gent., project for sweetening salt water. He procured an Act of Parliament to secure his invention.

1696. Patent to Colonel JACOB RICHARDS for a new invention to be made use of in any frigot or merchant ship for destroying any numbers of the enemy upon boarding the same. The Colonel lived at Greenwich, and he invited those who thought his invention would be useful to them to repair to him.

Patent to ROBERT LEDINGHAM, merchant, for chain pumps that discharge almost double quantity of water any yet have done, and in the same time and with the same strength, both from ships of war and merchantmen.

Patent to RALPH LANE, London merchant, for a new invention of making and producing figures in flowers and cloth, and all other woollen and silk manufactures whatsoever. This work was carried on in Mansel Street, Goodman's Fields. Any one sending their own cloth there had it flowered at reasonable rates.

Most of the paper made in England before the patent to the white paper makers' company was granted, in 1687, was of the coarse brown sort; white writing paper was had from abroad. On the war with France high duties were laid on imported paper, which led the English manufacturers to improve their production. Its quality kept steadily improving, and now the English workmen are so expert that Barilon, the French ambassador, is charged with having enticed workmen from the English mills into France.

Patent to J. SIMMONDS, for a machine for raising great quantities of water, worked either by hand, horse, wind, or water, in order to supply cities and towns, pumping of ships, draining of lands and mines, which hath been experienced in all respects far surpassing what hath hitherto been done, in particular that the greatest engine will not exceed a porter's burden.

The engine was worked at the White Lion and Crown, in Shoe Lane, and "raised 30 tuns in an hour, between 40 and 50 feet high, with the strength of two or three men."

English made sail cloth now exported.

JOHN MARSHAL, at the Archimedes, in Ludgate Street, grinds spectacles in brass tools, true according to the nicest rules of art.

Patent to EVAN JONES, Chester, a machine to grind corn. He erected his engine in Horsleydowne, Southwark, consisting of six mills, which were daily at work in one room in grinding of corne, and performed it with despatch, coolness of grinding, at the same time preserving colour of meal to advantage, without wind or water. The engine was convertible to supply the defects of wind and water in mills, forges, or water-works whatsoever.

1697. NATHANIEL GREWE, M.D., making and refining salts of the purging waters, The new salt was supplied in any quantity, very fine and cheap, by Mr. Thomas Tramel, overseer of the patentee's salt works, sign of the Cabinet, St. Paul's Church Yard. The true salt may be known from all counterfeits by its bitter taste.

Patent to JAMES VAN DALEN. Wagon with double troughs that shoot out their load at once, and return into their places again, and is wrought with a sort of scaffolds that may be removed entire; which will be found very proper and useful in such sort of works as require an expeditious removing of great quantities of heavy matter, and particularly in the making of rivers navigable and such like works.

Great riots among the silk weavers, in consequence of the silks, calicoes, and other productions of India being worn by the public in preference to English fabrics. The rioters failed in their attempt to get possession of the bullion that had been collected for exportation, and was about to be removed from the East India House to the ships.

1698. CALICO PRINTING is said to have been known in 1671. A patent for an improved machine was taken out in 1676, and the art was carried on in London in 1688, but most likely on a very small scale. In 1690 a small print ground is said to have been established on the Thames at Richmond, by a Frenchman, who is supposed to have been a refugee. The first considerable manufactory of printed calicoes is, however, considered to have been that formed at Bromely Hall in Essex, on the Lea. The first extension of printing is dated a year or two before King William's Act, prohibiting the importation of Indian and foreign silk, cotton, and printed fabrics. After that cloth printing made rapid strides in improvement, in a style of design evidently modeled to suit the public taste, which was formed from a long use and partiality to Indian productions.

Captain Thomas Savery invents a steam engine which he applies to raising water. Those who deny to the Marquis of Worcester the merit of having erected an engine, consider Savery's to be the first practical application of steam as a prime mover. He has displayed the most admirable ingenuity in the combination and adaptation of the details of this machine throughout.

Mr. Charles Ardesoif's new composition for the preservation of ships from the worms in foreign voyages, keeping them neat and clean in sailing, and saving the charge of sheathing. Of which an experiment was successfully made in his Majesty's ship the Deptford, in her late voyage to New York. When the Deptford was at Barbadoes, the composition lay on her bottom as firm as when laid on at first.

Patent to George Oldner and Andrew Prime, merchants, to prevent ships foundering at sea. This was experimented and well approved of by various persons.

A mill was erected at East Moulsey, Surrey, to make milled lead. The sheets were smoother and broader than those made by the same company in London, but the undertaking was finally unsuccessful.

Patent to John Reeve and John Groves, Chipping Norton, for making a malt drier upon iron, or iron plates tinned, whereby the malt is dried by near half the fuel, and in much less time than in the common way, without any danger of fire.

John Rice. An engine for grinding, cutting, polishing looking-glass plates, by which glass is truly ground and polished, with the best black polish, and also the borders cut most curiously *hollow*, and with a better lustre than any heretofore done. This was a coveted improvement, as being used by the Venetian makers to distinguish the finest plates for mirrors.

All sorts of looking-glass plates and coach plates were done at reasonable prices; the patentees had new invented frames for coach glass plates, or for windows, $\frac{3}{4}$ inch broad, and made of metal of a gold colour.

1699. Patent to Monsieur Allein, for the sole making of verdagreece; "other business hindering his going forward with it, Monsieur will dispose of patent tools, and instruct other persons how to make it."

Patent to John Yarnold. Engine for raising water, 120 tun 300 feet high in an hour; most useful for draining of mines, watering high places. He erected a model engine in Prescot Fields.

Glass Manufacture. The Glass Workers' Company in the Strand are still inferior to their neighbours, and incurring forfeitures under their patent for imperfect glass. The Bear Garden glass house, however, attained the art of making rough looking-glass plates in greater perfection and magnitude than ever before practised in England, and made plates from 45 to 100 inches long and proportional breadth.

"JOHN WALCOT, Gent., administrator of William Walcot, first and true inventor of making salt water fresh, hath lately caused said art to be practised.

"The ship Lucretia, Captain Saywell commander, from London to Jamaica and home again, great part of which voyage her ship's company was supplied with salt water made sweet by this contrivance."

Walcot's invention was carried forward by a company.

1701. Patent to Major ROBERT DOUGHTIE. New invention of converting raw hides and skins into good and beautiful leather without the use of oak bark, so that the timber may be greatly preserved for the use of his majesty's navy, as for the unduring, colouring, and beautifying of leather. "Which invention, in respect of its small disbursements for ingredients and the quick return of profits, being found to be of public benefit and advantage, the major was willing to dispose of the same, or to take in partners; for which purpose he attended daily at his chamber in the Charter House, London."

1703. "The so much famed 'Exchange Strops,' instead of hones, are described as ready *fixed on a board,* (which is the improvement,) and will set even lancets."

The cotton trade was now taking deep root. In 1697, 1,976,359 lbs. of cotton wool had been imported, and this year 1,985,868 lbs. is the weight of the raw material brought into the country. The method of spinning it into yarn is considered to have been as rude as that followed in India from the earliest times.

EPHRAIM How, a celebrated knife cutler at this time. Other artists forged his trade marks.

1704. Patent to Mr. NICHOLAS FACCIO, gentleman of the Royal Society, PETER DEBAUFRES, and JACOB DEBAUFRES, watch makers. New art of figuring or working precious stones, crystal, or glass, and certain other matters different from metals, so that they may be employed in watches, clocks, and many other engines, as an internal and useful part of the engine itself, in such matters as never were yet in use.

At Debaufres', Church Street, St. Annes, they exhibited jewel watches, and some essays of free watches, and wholly free watches, which all belonged to the same art.

1705. Some years before this, SIR CARBERRY PRICE divided the profits of his lead mines in Cardiganshire into 24 shares. A company was formed in 1693, with the Duke of Leeds as its governor, and Sir Humphry Mackworth, who had acquired Sir C. Price's interest in the mines, as deputy governor, and a committee of management. The original shares were now subdivided into 4,008 shares, entitled for 22½ years to a proportion of the profit from making lead and silver. These shares were disposed of by a lottery, composed of 25,000 tickets at £5 each; 2,500 of which were to be "fortunate," and the rest uncertain, with a number of perplexing, mystifying clauses. One-twelfth of the whole profit was to be set aside for charitable purposes. Sir Humphry was acting manager, and he formed wharfs, warehouses, furnaces, and other buildings on his own lands with the company's funds, raised lead ore, extracted silver, for several years; and by sham statements of every kind, issuing notes, and other bad tricks, the company's concerns were made to appear so prosperous, that their stock rose to an extraordinary premium. The whole affair was a great juggle and fraud, and the end had never been doubtful, though the stockholders were blind to the ruin before them. The bubble of the mine adventurers burst a few years afterwards, and many thousands of persons were reduced to beggary.

1706. Patent to **Henry Mill**, Gent., for certain steel springs, invented for the ease of persons riding in coaches, which are absolutely differing from those springs hitherto used, both in species and position, and in their use do much excel them. They did not exceed 20 pounds in weight, nor require any longer perch than what is common, so as to render the draught any thing the heavier to the horses. They were fixed to any coaches, chariots, calashes, or chaises, and might be removed at pleasure from under one coach to another in the space of half an hour. They were sold at 90 shillings the set.

Whereas her majesty, by order in council of 25th April last, was pleased to refer unto Mr. Attorney and Mr. Solicitor General the petition of **Francis Moult** and others, praying to vacate Letters Patent granted to Robert Lydal, of Truro, Cornwall, Gent., for the sole use of a new invention of smelting and melting black tin ore into white tin, by culm and sea coal, in a blast furnace called *igni furens;* and for refining and separating gold and silver from tin, by precipitation, as being the same invention for which he had formerly obtained Letters Patent, dated 30th June, in the 1st year of our reign, for smelting and melting black tin ore into a white merchantable tin, in a reverberating furnace, without the help of bellows, by means of some peculiar fluxes, and for a valuable consideration assigned to the petitioner.

Found: Letters Patent were for same invention, and were unjustly obtained, and upon false suggestions; and Second Patent is thus made null and void.

Patent to **Robert Aldersey**, citizen of London, for a floating damm, whereby he is capable of carrying barges, lighters, and other vessels over the greatest flats and shallows in any navigable river. "The invention hath been experimented upon, and received the approbation of the most eminent mathematicians in the kingdom."

1707. Patent to **Thomas Savery**, Esq., for double hand bellows, which, by the power of springs and screws, produces a continual blast, notwithstanding the suction, by which any sort of metal may be melted in a common wood or coal fire; and will be useful in particular for making and raising fires in all private families, and also to all persons working in metal or ore, who may, by proper flux and help of these, melt them in a common furnace.

This patentee was one of the celebrated inventors of the steam engine.

1708. Patent to **George Fernal**, for an excellent way of making a wall or work in the water, which shall turn any river or running water, though it were 100 yards over or more, which can be sunk down, taken up, and carried off in one day, being serviceable for that purpose. He can also cut through a bank of sand, turning the old channel through it, and, raising up the ground, dissolving it, and forcing it to fly away with the water, which he did perform at the River Dee, July 25, 1707; for in less than 1 hour, in 120 yards in length, he run off upwards of 200 tuns of sand. Also, when men cannot work for cold, he can dissolve a bank and run it off, no man working at it (rocks excepted). If any desire to have a river of water turned another way, or a rock of sand that is offensive to any part removed out of the way, they may send for him, at his dwelling house, at West Chester, to any part of Great Britain. He will come and perform any thing he mentions on reasonable terms.

In 1710 an Act was passed for the encouragement of learning, by which a better protection than heretofore was given to the rights of literary invention and labour; and, above all, authors were emancipated from the bondage of licenses and letters patent. The rights of mechanical inventors were, however, allowed to remain on their ancient footing, to be exercised only under a grinding and devouring royal grant, described as the free gift of the sovereign, which emanates from her Majesty as the patron of the arts and sciences, at the humble request of her subject, to whom, as a gracious favour, she extends her royal protection.

PRACTICAL AND EXPERIMENTAL

RESEARCHES IN HYDRAULICS.

By R. A. PEACOCKE, C.E.

A

ABSTRACT OF CONTENTS.

Laws of Physics are Mathematical Laws. The discovery of these Laws is the limit of human penetration. —Instances given.—Although our knowledge is so limited, an acquaintance with these laws is most important.—Science of Hydraulics in a very backward state.—Proposition that,

1. Curve of Spouting Water;
2. Curve of Ebb and Flow of the Sea;
3. Curve of quantity of Water discharged through pipes;

although they are instances of water in motion under very different circumstances, are yet governed by a uniform Mathematical Law.—The few exceptions to this law accord with each other even in their anomalies. —Definition of this Law of Hydraulics.—Proof by numerous comparisons of Calculation and Experiment. This is important, because the extensive applicability of a particular Law tends to prove the universal applicability of that Law.

SECTION I.

Apparatus for measuring Curve of Spouting Fluid.—Tables showing comparatively the results of Experiment and Calculation.—Formula in detail, and its application.—The Hydraulic Curve is seldom a Parabola.—Diagram 1.

SECTION II.

Apparatus for taking Observations to determine the Curve of Ebb and Flow of the Sea.—Table of Observations.—Method of projecting the Observations.—Diagrams 2 and 3.—Table of Observations arranged in " Divisions."—Calculation by the Formula accords with Experiments.—Curve is proved (as in case of Spouting Fluid), not to be a Parabola.—Formula same as for Curve of Spouting Fluid.

SECTION III.

Curve of increasing Discharge of Water through pipes is governed by same Law as Curves of Spouting Fluid and Ebb and Flow of Sea.—Various Formulæ for calculating Discharges of Water through pipes.— Smeaton, Prony, Young, Dubuat, Eytelwein, Genieys.—Description of some Experiments made by Mr. W. A. Provis.—None of the formulæ of the six gentlemen named accord with Experiments.—Table and Calculations prove that the difference is considerable.—New Formula applies to the Experiments, and accords with them.—It follows from the Formula that the Curve is not a Parabola.—Application of Formula to Experiments by Abbé Bossut, by M. Couplet, by Chev. Dubuat, and by Mr. Smeaton. Application of Formula to discharges by pipes of which the diameter is increased at every Experiment. Diagrams 4, 5, and 6.

It follows, then, that the several cases of fluids in motion are governed by a uniform Mathematical Law.

APPENDIX.

Tables of average Discharges of Pipes used in Mr. Provis's Experiments, calculated by Formula.

Quotations from evidence taken before Health of Towns Commission to prove the great importance to the working classes of an abundant and cheap supply of water. Cheap supply proved to depend materially on a correct formula for calculating the discharges of water through pipes.

PRACTICAL AND EXPERIMENTAL

RESEARCHES IN HYDRAULICS.

By R. A. PEACOCKE, C.E.

PART I.

There is a certain impassable limit to all human discoveries in physics. Philosophers commence their researches in any given department of science by observing facts. They collect and compare their own observations and those of others, and ultimately discover some series of fixed and simple laws, (generally *mathematical* laws,) to which all the phenomena of the given department of physics may be referred. These laws are to be considered *elementary*. For in seeking to understand and discover the laws of nature, no human subtlety can extend beyond them.

Of this kind are some of the discoveries of Kepler; namely, that the squares of the periodic times of the planets are proportional to the cubes of the greater axis of their orbits. Also that the same relations exist between the planet Jupiter and his satellites, for the squares of the periodic times of the satellites are proportional to the cubes of their distances from Jupiter's centre[a]. Falling bodies are in like manner known to be governed by fixed and simple mathematical laws. A body falls 16 feet during the first second of time, during the next it falls 48 feet, during the third it falls 80 feet, during the fourth it falls 112 feet, continuing to fall during every successive second 32 feet more than during the preceding second[b]. The law of universal gravitation propounds that—All the particles of matter mutually attract each other in proportion to their masses, and inversely as the squares of their distances[c]. This grand discovery of the immortal Newton is a case in point. Of the same nature are chemical equivalents, of which an instance is given below.

[a] Cyclop. Brit., vol. iii. p. 101.

[b] Cyclop. Brit., "Dynamics," p. 465.

[c] Cyclop. Brit., "Astronomy," p. 122.

	Atoms or equivalents of nitrogen and oxygen.
1 atom of the protoxide of nitrogen consists of . .	1 + 1
1 atom of deutoxide	1 + 2
1 atom of hyponitrous acid	1 + 3
1 atom of the nitrous acid	1 + 4
1 atom of the nitric acid	1 + 5[a]

It would be easy to multiply instances of this sort, but sufficient cases have already been quoted to prove amply that *many of the elementary principles of science consist of simple and fixed mathematical laws.*

No human penetration ever yet extended further into the secrets of nature than the discovery of these laws. But although our knowledge is thus limited, it is of the greatest importance to attain a complete acquaintance with these laws in every branch of science, for many purposes of the most obvious practical use to mankind.

It is generally acknowledged that the science of *hydraulics* is in a very backward state. And though the main object of this paper is *an inquiry into the law of the discharge of water through pipes for the purposes of hydraulic engineering*, yet it occurred to me that the curve described in air by some spouting fluid which I casually saw, the curve of ebb and flow of the sea which had been seen graphically represented, and the curve of discharge through pipes which I had myself drawn on paper, appeared to the eye to have a *certain resemblance in form*;—which, if on inquiry it turned out to be an *actual* and *mathematical* analogy, would of course imply that SOME PARTICULAR LAW WAS COMMON TO THEM ALL. And into this preliminary inquiry, with respect to the laws of spouting fluids and ebb and flow, it was thought desirable to enter, because *an extended application of a particular law* TENDS *to prove the universal applicability of that law.* Accordingly inquiry was attempted whether there is *any*, and if so, *what* analogy between the various cases of "fluids in motion," which are the subject of the following paper: namely,

1st. The curve formed by spouting water at liberty in the atmosphere.

2nd. The curve of ebb and flow of the sea.

3rd. The curve of discharge of water through pipes of constant lengths and diameters, but *variable heads.*

4th. The curve of discharge of water through pipes of constant diameters and heads, but *variable lengths.*

5th. The curve of discharge of water through pipes of constant heads and lengths, but *variable diameters.*

That a simple and fixed mathematical law prevails throughout the numerous experiments discussed in this paper, in all the five cases of fluids in motion, we shall see ample proof. The very few cases where the experiments do not accord with this law are specified, and do not amount to a greater number of exceptions to a comprehensive general rule than might reasonably have been expected. Though one or more individual curves deviate from the general law in each of the five classes; these deviations yet accord with each other *even in their anomalies.* Co-efficients 2 and 3, (p. 9,) apply to every case which co-efficient 1 does not apply.

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[a] Brande's Manual of Chemistry, vol. i. p. 217.

This law of hydraulics may be expressed thus: *The hydraulic curve consists of ordinates of a parabola*[*] PLUS (*sometimes* MINUS) *a certain constant quantity which increases arithmetically as the corresponding abscissæ increase.*

Is it not something in favour of the formula that it is simple and uncomplicated in its nature, like the important laws of physics just specified?

The proofs are of the best kind. The results of experiments, and the calculations by the new formula, are placed side by side in parallel columns of figures. And the average agreement of experimental with formular quantities will of course be a measure of the accuracy and applicability of the formula. This rigid mode of comparison will be found favourable to the formula.

It is difficult to our first thoughts to conceive that there can be any analogy between the operations of fluids in motion under such very different circumstances as in the five cases mentioned: viz., that the immense body of water in the ocean should obey a precisely similar law to that which governs the curve described by a minute quantity of the same element flowing from a small horizontal tube into the atmosphere, and that the law of nature which obtains in both these cases should likewise govern the *quantities* of water discharged from pipes, however those quantities may be increased or diminished by the greater or less *lengths* and *diameters* of the pipes, or the greater or less column of water employed to produce the discharge. These facts are curious in themselves, and also important.

They are *important* for the reason already given; namely, that the *extensive applicability of a particular law* TENDS *to prove the universal applicability of that law.*

When the curves of spouting fluid and of ebb and flow have been disposed of in Sections I. and II., next, in Section III., six different formulæ, invented respectively by Messrs. Smeaton, Young, Prony, Eytelwein, Dubuat, and Genieys, and another formula given in "Young on Eytelwein," making together *seven formulæ for calculating the discharges of water through pipes,* are applied each to the calculation

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[*] Wherever the words "parabola," "theory of parabola," "curve of parabola," &c., are used in this essay, it is intended to be understood that the horizontal distances or ordinates are taken to be as the square roots of the heights or abscissæ.

of the (supposed) discharge of water through a given pipe, under given circumstances. Each formula is used according to its author's (or his editor's) directions. And the results are given in figures, which are also projected for the convenience of comparison in Diag. 4. The actual discharges ascertained by *most satisfactory experiments*[a], with the given pipe under the given circumstances are also projected. The result of this comparison is, that *none of the seven formulæ fulfil the requirements of the case by producing the correct discharge of water through pipes.*

The new formula applies with great accuracy to the case in question[a]. It is also applied to many other series of experiments on the discharge of water through pipes with satisfactory results. It dissipates (to an extent proportioned to their accuracy and number) the unavoidable errors incurred in making *experiments*, and enables us to calculate from the experiments to such extent freed from errors, as a basis, the operations of nature in the given case *ad infinitum.*

And lastly, by means of experiments and calculations made as aforesaid, it furnishes us with a basis for *other and further calculations.* This last is illustrated *specifically* by the text and table at pages 57, 58; and *graphically* by Diagram 6; where it is shown how, by taking the facts first calculated in connection with other facts as a new basis, the formula enables us to calculate *still further results ad infinitum.*

The laying down of a correct universal law for calculating the discharges of water through pipes *involves much calculation*, and is altogether a large question. It is anticipated that in this paper *something has been done towards its solution.*

SECTION I.

DESCRIPTION OF THE APPARATUS FOR MEASURING THE CURVE OF SPOUTING FLUID, AND OF THE METHOD OF TAKING THE MEASUREMENTS.

To measure the curve of spouting fluid, the following apparatus was used:—

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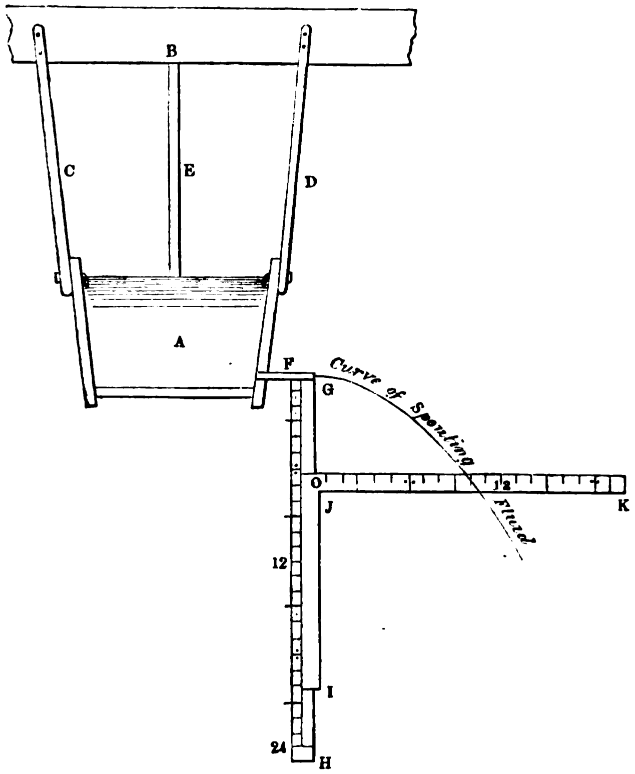
[a] This will be seen very clearly by referring to the graphic representation, Diagram 4, and the line marked TRUE DISCHARGE. On and near this line will be observed the marks ⊡ × ⊙ +, which indicate the results of a number of experiments all correctly projected on the equal squares of the diagram in their proper places. And it may be fairly gathered:—

1st. That these experiments must be very correct, because they agree so well one with another. 2nd. That the small black dots, (being points found by the formula,) projected in the same manner as the experiments arrange themselves by passing through the centres of the several groups of experiments, in a manner so satisfactory as to afford a strong proof of the accuracy of the formula.

A more particular account of these experiments will be found in Transactions of Civil Engineers, Vol. II. p. 201, &c., and also at p. 35 of this Essay.



A is a section of a wooden vessel containing water, which, for the greater convenience of making experiments, was suspended in a fixed and steady position from the beam B, by wooden stays, C E D. A small tube, F, communicating with the water, was inserted in the side of the vessel, near the bottom. In the outer end of this tube a plug was inserted, which was removed when an experiment was to be made. G H is a staff, fixed vertically by a plumb line, and graduated into inches, zero being the end of the tube. In a groove in this staff, a carpenter's square, I J K, works, the upper edge of which is also graduated into inches, and its zero placed vertically under the outer end of the tube.

A visible mark was made inside the vessel A, to show the height at which it had been previously determined the surface of the water should be constantly kept; and an assistant was placed with another vessel in his hand, to supply water in a regular stream, exactly as fast as it was discharged by tube F, which, after a little practice, he was very successful in doing. There was also a small apparatus fixed to keep the surface of the water in vessel A steady, which it is immaterial to describe. A second assistant was also ready to note down the measurements as they were given out. He had a small book, ruled with proper columns, and the heights (on the vertical staff, G H) at which it had been previously determined horizontal distances should be measured, previously written down. To use the square, I J K, and measure horizontal distances to the stream of the flowing water, was my business.

When all was ready I removed the plug, and allowed the water to flow freely from tube F. After having waited until oscillation of the stream had ceased, and the water flowed regularly and equally, I commenced making horizontal measurements to the intersection of the *curve of spouting fluid,* with the graduated edge of the square, and called out the results to the second assistant, who immediately wrote them down.

Thus, in experiment 1, at one inch on the vertical staff the horizontal distance to the centre of the spouting water was firstly 4.1, and secondly 4, giving an average of 4.05. At two inches on the staff the horizontal distance was 5.6 inches, and so on. The experiments were (with one exception) made in duplicate, to guard against errors, and where the two results did not agree sufficiently near, a third experiment was made.

The following is an account of the experiments :—

EXPERIMENT I.

Tube 2.86 inches long, its inside diameter .23 inch. Thermometer in air, 52½°, in water also 52½°. Constant depth of water, 7 inches.

Depth from the end of the Tube on Vertical Staff.	Horizontal distance from the end of the Tube to the Curve of Spouting Water.		By theory of Parabola.	Calculated by formula with constant quantity of Order 1[a]. See p. 9.	Observations.
Inches.	First Experiment.	Second Experiment.		C.F. = —.07	
1	4.1	4.	4.05 A	4.05 A	
1¼	4.5	4.5			
1½	5.	4.85			
1¾	5.26	5.2			
2	5.6	5.6	5.72	5.66	
2¼	5.9	5.9			
2½	6.2	6.2			
2¾	6.4	6.5			
3	6.8	6.8	7.01	6.87	
4	7.85	7.7	8.1	7.89	
5	8.85	8.7	9.05	8.77	
6	9.5	9.5	9.92	9.57	
7	10.2	10.2	10.72	10.29	
8	11.	11.	11.46	10.97	
9	11.7	11.7	12.15	11.59	
10	12.1	12.2	12.8	12.17	
11			13.43	12.73	
12			14.03	13.26	
13			14.60	13.76	
14			15.15	14.24	
15			15.69	14.71	
16			16.2	15.15	
17			16.7	15.58	
18			17.18	15.99	
19			17.65	16.32	
20			18.11	16.71	

The formula used to calculate the quantities in column 5 consists of two processes, which will be best illustrated by examples.

The mean of the two horizontal distances ascertained by experiments for 1 inch depth, viz., $\frac{4.1 + 4}{2} = 4.05$ and this quantity (4.05) is placed at the head of the fifth column, and marked with the letter A, signifying that it is *assumed* to be correct, and used as a basis to calculate with.

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[a] This sort of constant quantity I will, for the sake of brevity, call a *factor*, and it will in the tables be distinguished as C. F. or V. F., acccording as it happens to be a *constant* factor, or a *variable* factor.

Then supposing the horizontal distance opposite five inches were required?

Here we say, $\sqrt{1} : 40.5 :: \sqrt{5} : 9.05$.

This is the first process, and gives the quantity in the fourth column. But since this exceeds the quantities ascertained by experiment, something must be deducted from it. And it has been found by experience, that the quantity .07 taken once for every inch by which the depth whose horizontal distance is required exceeds the depth assumed, deducted from the result of the first process, will leave the result required.

Thus, 5 inches (the depth whose horizontal distance is required),

Minus 1 inch (depth assumed),

Leaves 4 inches, which $\times$ .07 = .28.

And $9.05 - .28 = 8.77$, the result required, (see column 5,) which agrees nearly with the two experiments 8.85 and 8.7.

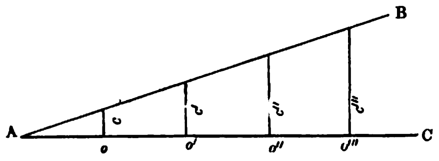
Again, let the horizontal distance opposite 10 inches be required.

Then $\sqrt{1} : 4.05 :: \sqrt{10} : 12.8$ and $(10 - 1) \times .07 = .63$, which deducted from 12.8 gives 12.17, as in column 5.

Thus, the quantity .07 (called for the sake of distinction a factor) INCREASES ARITHMETICALLY AS THE DEPTH INCREASES. It is written at the top of column 5, with the sign − before it, to signify that the sum of the factors must be *deducted.* Because, in many cases, as we shall see hereafter, the amount of the factors must be *added.* This process of calculation has been continued to a depth of *twenty inches,* and doubtless gives approximately accurate results. IT THUS EXTENDS OUR KNOWLEDGE OF FACTS, for the experiments cease at ten inches.

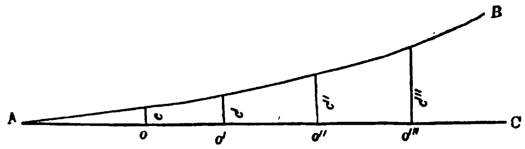
It will be seen by comparison that the calculated quantities in column 5 agree very nearly with experiment. This will also be seen by referring to Diagram 1, Fig. 1, where the experiments are correctly represented by points inclosed within the small circles, thus ⊙ or thus Θ, with which the curve line, drawn by hand through points found by projecting the calculated quantities in column 5, agrees very well. The dotted curve line represents the quantities obtained by the theory of the parabola in column 4, which *do not* agree with the experiments, as some persons erroneously suppose they do.

No. 1.



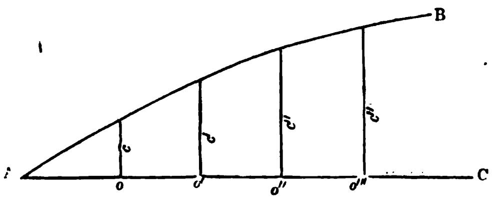
Constant Factor (C.F.)

No. 2.



Variable Factor (V.F.)

No. 3.



Variable Factor (V.F.)

The above sketches convey a graphic idea of each of the several kinds of factors mentioned in this paper. The first is of by far the most common occurrence, and is of the same nature as the factor for experiment 1 just now mentioned, and as all those used in the subsequent calculations, except where otherwise stated. The lines A B, A C, are supposed to be continued ad infinitum, and the cofactor *c* is equal to the length of a line drawn vertical to A C, until it intersects A B from a point *o* in the line A C corresponding with such factor[a].

---

[a] Having decided on bringing my humble inquiries before the public, I have thought right to make them as extensively intelligible as I could; and for that purpose have avoided making any use of algebraic expressions in explaining my method of making the calculations. In stating the formulæ of Dr. Young and others, however, I had of course no choice but to make use of the exact terms employed by the authors of the several formulæ.

EXPERIMENT II.

This experiment was made with the same tube as Experiment 1. Thermometer in air 50°, in water also 50°. Head of water, 6 inches.

Depth from the end of the Tube on the Vertical Staff, in inches.	Horizontal distance from the Vertical Staff to the Curve of Spouting Water, in inches.	By theory of Parabola.	Calculated by formula. C.F. = — .09.	Remarks.
1	3.95	3.95 A	3.95 A	
2	5.26	5.59	5.5	
3	6.4	6.87	6.69	
4	7.3	7.9	7.63	
5	8.2	8.83	8.47	
6	8.95[a]	9.68	9.23	[a] First shows a disposition to break into drops, and a little oscillation commences.
7	9.5	10.46	9.92	
8	10.2	11.17	10.54	
9	10.8	11.85	11.13	
10	11.4	12.49	11.68	
11	11.95	13.1	12.9	
12	12.2	13.68	12.69	
13	12.8	14.24	13.16	
14	13.2	14.78	13.61	
15	13.6	15.3	14.04	
18	14.9	16.76	15.23	
21	16.	18.1	16.3	
24	17.2	19.35	17.28	
27	18.4	20.52	18.18	
30	19.2	21.63	18.82	
33	20.	22.69	19.81	
36	21.	23.7	20.55	
39	22.	24.67	21.25	

In Experiment 2 the calculations are made as before; for example, supposing the horizontal distance from the vertical staff at a depth of 12 inches is required, then we say, *assuming* 3.95 as before,

$\surd 1 : 3.95 :: \surd 12 : 13.68$ = parabola, as in column 3.
$12 - 1 \times .09$ $\quad$ $\underline{.99}$ deducted.

Correct horizontal distance by formula 12.69, as in column 4.

Proceeding in like manner, we obtain all the other quantities given in columns 3 and 4. And it will be seen on comparison that the quantities in column 4, calculated by formula, agree approximately with the results of experiment given in column 2. But the quantities in the column headed "Theory of Parabola," do *not* agree with experiments[*].

EXPERIMENT III.

Same apparatus as in Experiment 2, but with a head of 3 inches.

Depth from the end of the Tube on the Vertical Staff.	Horizontal distance from the Vertical Staff to the Curve of Spouting Water, in inches.		By theory of Parabola.	Remarks.
Inches.	Experiment I.	Experiment II.	See fig. 3, diagram 1.	
1	2.4	2.4	2.4 A	
1¼	2.6	2.65		
1½	2.8	2.9		
1¾	3.1	3.2		
2	3.3	3.4	3.39	
2½	3.7			
3	4.1	4.	4.157	
3½	4.5			
4	4.7	4.6	4.8	
5	5.3	5.1	5.37	
6	5.8	5.6	5.88	
7	6.3	6.1	6.35	
8	6.7	6.6	6.79	
9	7.	7.1	7.2	
10	7.4	7.65	7.59	
11	7.7	8.1	7.96	
12	8.1	8.6	8.31	
13	8.35	8.9	8.65	
14	8.8	9.1	8.98	
15	9.	9.3	9.29	
18	9.85	10.2	10.18	
21	10.7	10.9	11.	
24	11.5	11.4	11.76	
27	12.	12.	12.47	
30	12.5	12.8	13.14	
33	13.1	13.7	13.79	
36	14.	14.6	14.4	
39		15.2	14.99	

---

[*] At the conclusion of the experiments it was found that the vertical staff (which had occasion to be refixed at the commencement of this experiment) was accidentally so placed that one inch upon the staff was 1 $\frac{2}{10}$ inch below the bottom of the tube. And therefore, in strict accuracy, each of the following *depths* ought to have $\frac{2}{10}$ inch added to it. But the difference made in the calculations by the accident is wholly immaterial.

In this case the quantities by theory of parabola, though they agree nearly with experiment, are nearly all in excess. They agree so nearly, that we do not think it of consequence to ascertain the precise extent of the difference; it is evident, however, that the deduction of a small factor would make them accord more nearly, and so be a better approximation than the theory of the parabola. This is apparent by comparison of the quantities in column 4 with those in columns 2 and 3.

By the deduction, therefore, of a small factor, we can find points in the hydraulic curve as before.

EXPERIMENT IV.

Pipe, 6 inches long. Thermometer in air, also in water, 49½°.
Head of water, 3 inches.

Depth from the end of the Tube on the Vertical Staff.	Horizontal distance from the Vertical Staff to the Curve of Spouting Water, in inches.		Parabola.	Calculated by formula. See fig. 4, diagram 1. C.F. + .08.	Remarks.
	1st Exper.	2nd Exper.			
1	2.05	2.	2.025 A	2.025 A	
2	3.1	3.05	2.86	2.89	
3	3.75	3.7	3.51	3.57	
4	4.35	4.2	4.05	4.14	
5	5.	5.	4.53	4.65	
6	5.2	5.4	4.96	5.11	
7	5.75	5.7	5.36	5.54	
8	6.2	6.	5.73	5.94	
9	6.6	6.6	6.07	6.31	
10	6.9	6.95	6.4	6.67	
11	7.3	7.35	6.72	7.02	
12	7.6	7.8	7.01	7.34	
15	8.7	8.5	7.84	8.26	Water begins to break into drops.
18	9.4	9.2	8.59	9.1	
21	10.	10.	9.28	9.88	
24	10.7	10.6	9.92	10.61	
27	11.5	11.35	10.52	11.3	
30	12.1	12.2	11.09	11.96	
33	12.5	12.75	11.63	12.59	
36	13.1	13.4 13.25	12.15	13.2	
39	13.7	14.3 13.8	12.65	13.79	
42	14.2	15. 13.5	13.12	14.33	
45	14.5	14.2 14.2	13.58	14.9	
48	14.9	15. 14.6	14.03	15.44	

In this case the quantities found by theory of parabola (though they agree nearly with the experiments) are all too little. Consequently, the *addition* of a small factor makes them agree better, and the hydraulic curve may be produced as before. Accordingly, by the formula we obtain the quantities in column 5, which agree better than those by the parabola, with the experiments, as will be seen by examining the table. In this case the arithmetically increasing factor .03 is *added*, instead of being *deducted*.

EXPERIMENT V.

Pipe, 6 inches long. Bore, $\frac{1}{18}$ inch. Thermometer in air, 49½°.
In water, 50½°. Head of water, 7 inches.

Depth from the end of the Tube on the Vertical Staff.	Horizontal distance from the Vertical Staff to the Curve of Spouting Water, in inches.		By theory of Parabola.	Remarks.
	1st Exper.	2nd Exper.		
1	3.6	3.5	3.55 A	
2	5.1	4.8	5.02	
3	6.3	6.1	6.15	
4	7.25	7.	7.1	
5	8.	7.85	7.94	
6	8.8	8.5	8.7	
7	9.65	9.2	9.39	
8	9.8 10.4	10.	10.04	
9	10.5	10.5	10.65	
10	11.1	11.2	11.23	
11	11.9	11.65 11.8	11.77	
12	12.35	12.1	12.30	
15	14.	13.6	13.75	
18	15.3	15.9	15.06	
21	16.5	16.1	16.27	
24	17.75	17.2	17.39	
27	18.7	18.2	18.45	
30	19.7	19.25	19.44	
33	20.7	20.1	20.39	
36	21.6	21.1	21.3	
39	22.4	22.	22.17	
42	22.7 23.5	22.8	23.	
45	23.4 24.3	24.01	23.814	

Here the theory of the parabola applies to the experiments with great precision, no co-efficient is required.

Our account then stands thus:—

To four out of five experiments on the curve of spouting fluid at liberty, our formula applies with considerable accuracy. The fifth experiment obeys the law of the parabola. The parabola appears therefore to be the exception to the rule.

Now taking the first four experiments (out of five, the whole number made), we have seen that our formula approximately accords with the law of nature, that law having been ascertained by the experiments. The co-efficients are all of the Order 1 (p. 9).

Without inquiring into the values of the separate forces (such as gravity, friction, resistance of the air, and so forth) which *combined* produce this law, it is sufficient to take them in the aggregate. And we know that no new force enters into the law, after the experiments have ceased.

The formula therefore fulfils the requirements of the case, and enables us to extend our knowledge of facts.

In Exp. 1. The factor is −.07
,, 2. Ditto −.09
,, 3. Ditto −. a minute quantity not ascertained
,, 4. Ditto +.03
,, 5. Ditto 0

On comparison of these factors, and consideration of them with reference to the lengths and diameters of the tubes, and the amounts of "head"—it is not observable that the factors follow any definite law; though it is probable that a greater number of experiments would have proved the existence of a definite law. But the farther prosecution of the subject in that way, though it would have been interesting, was not necessary to my present purpose.

Diagram 1 shows the preceding experiments isometrically projected to a scale of one-fifth of the natural size.

The discharging ends of the tubes are supposed to be at points 0, on the top horizontal line. The vertical staff is represented by the vertical line commencing in each case at point 0. Each vertical line is graduated into inches as the staff was; and the top horizontal line is also graduated into inches in the same manner as the upper edge of the moveable square.

The dot in the centre of each minute circle, thus, ⊙, shows each of the *horizontal distances* ascertained by the experiments projected opposite its proper *depth.*

When the duplicate experiments have agreed very nearly, they are sometimes both contained within the small circle, thus, Θ; and where the duplicate experiments agreed exactly, that fact is denoted by a small figure 2 placed near the small circle.

The black lines are obtained in the following manner:—

The quantities given in the Tables of Experiments under the head of "calculated by formula," are isometrically projected, each from its proper *depth*, in the same manner as the *horizontal distances* obtained by experiment were projected; and the black line is then drawn by hand through each of the points so found; and it will be seen that such line follows the average of the experiments in a satisfactory manner.

Toricelli, in his work, "De motu gravium naturaliter accelerato, 1643," first gives the origin of the proposition, "*the velocities of issuing fluids are as the square roots of their depths.*" Since his time many others have supposed that this rule holds good in various cases of fluids in motion; as, for example, it has been supposed that the discharge through a pipe is,

1. Directly as the square root of the *head.*
2. Directly as the square root of the *diameter.*
3. Inversely as the square root of the *length.*

The theory of the parabola means precisely the same thing, being merely a different form of expression.

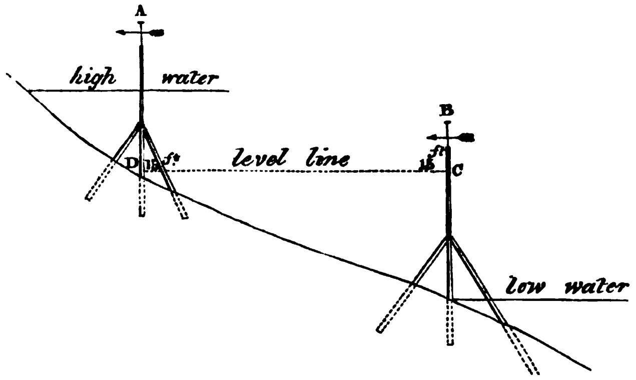
For if we call the depth the *abscissa,* and the velocity the *ordinate;* according to the rules given in treatises of geometry for calculating parabolas—"As the square root of a given abscissa is to its ordinate, so is the square root of any other abscissa to its ordinate."

Mr. Smeaton and other eminent men supposed that the discharge of pipes is "directly as the head of water, and inversely as the length of pipe;" this is also the *theory of the parabola.*

It will be part of our duty to examine, as we proceed, how far this theory accords with the facts we bring forward. And first we have seen that it *does not accord* with the results of four sets (out of five) of the experiments already detailed.

SECTION II.

OF THE HYDRAULIC CURVE OF EBB AND FLOW OF THE TIDE.



The sketch in the margin shows the two staffs, A and B, firmly fixed in the sand, and kept steady by sloping supports at the bottom[a]. These staffs were graduated into feet and inches, commmencing with zero near the bottom of the staff B, which was graduated up to the top, C, (say) 15 feet. A level line was then carefully carried by means of a spirit level, from the top, C, to the bottom, B, of the second staff, where 15 feet were also figured. And then the second staff, A, was figured and graduated in like manner to above the level of high water in spring tides. On the top of each staff was a moveable arrow and cross, with N.S. E.W., to indicate the direction of the wind.

To get rid as much as possible of oscillation produced by the waves, a tin cylinder open at both ends, of 15 inches diameter and 4 feet long, was suspended by a cord passing over a pulley at the top of each staff. One of these cylinders enclosed each staff, and by means of the cord and pulley could be raised or lowered at pleasure. Each cylinder opened at the side to enable the assistant to take it off and place it above or below the point where the supports abutted against the staff, as the rise and fall of the tide required. When observations were being taken, the cylinder was suspended so as to be about 3 feet below the surface of the water and 1 foot above it. This, when the wind was slight, had the effect of making the water within the cylinder and in contact with the staff absolutely still. And even when the wind was brisk, the only effect produced inside the cylinder was to cause the water to rise and sink in a steady manner to the extent of a few inches. In this latter case the observer carefully noted the extremes to which the water rose and fell on the staff, and registered the mean height as correct. Two watches were used, which by means of an excellent astronomical clock in the possession of my friend, John Higgin, Senior, Esq., of Greenfield, near Lancaster, were made to accord with Greenwich mean time. The observations were taken under my directions by one of two careful persons, who relieved each other at stated times*.

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[a] This apparatus was fixed in Morecambe Bay, near the village of Poulton-le-Sands, four miles west of Lancaster.

Tide Observations in Morecambe Bay, near Poulton-le-Sands, four miles west of Lancaster, taken at regular intervals of sometimes ten minutes, and at other times five minutes, as stated in the table. Commencing at 5h. 0m. p.m., July 5, 1843, and continued without interruption for 24 hours.

1843.	Greenwich Mean Time. P.M.	Height of Tide on Staffs.	Remarks.
	h. min.	ft. in.	
July +	5 0	23 4½	
	5 5	23 4¾	High water. Wind E.S.E.
	5 10	23 4¼	
	5 15	23 3¾	
	5 20	23 3	
	5 25	23 1¾	
	5 30	23 1	
	5 35	22 11	
	5 40	22 9½	
	5 50	22 5¼	Breeze stronger—a moderate breeze.
See Diagram 2. Division 1.	6 0	22 0	
	6 10	21 5½	
	6 20	20 10½	Breeze increased considerably. Thunder and lightning.
	6 30	20 5¾	Breeze diminished, and at 6 h. 35 m. changed to S.W.—a moderate breeze.
	6 40	19 11	W.S.W.
	6 45	19 7¼	
	6 50	19 3¾	
	7 0	18 9¼	
	7 10	18 3	S.E., gentle breeze.
	7 20	17 6½	
	7 30	16 10	
	7 40	16 0	
	7 50	15 3	
	8 0	14 6½	
	8 10	13 9½	
	8 20	12 11¾	
+ Division 1.	8 30	12 4	
	8 40	11 8½	
	8 50	11 0	S.W.
	9 0	10 5	
	9 10	9 9½	
	9 20	9 3	
	9 30	8 3?	
	9 40	8 0	
	9 50	7 5	
See Diagram 2. Division 2.	10 0	6 10	
	10 10	6 3	
	10 20	5 9½	
	10 30	5 3	
	10 40	4 10	E.S.E.
	10 50	4 5½	
	11 0	4 2	S.E.
	11 10	3 11½	
	11 20	3 10½	
	11 25	3 9¼	S.
	11 30	3 8¼	
	11 35	3 8	
+	11 40	3 8	S.W. Low water.
	11 45	3 8	
	11 50	3 8¼	
	11 55	3 8½	

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* The tides flow nearly from South to North, and (of course) ebb in the contrary direction. These observations were continued from July to September, 1843, but I have only found occasion to use a few of them for my present purpose.

	Greenwich Mean Time. P.M.		Height of Tide on Staffs.		Remarks.		Greenwich Mean Time. A.M.		Height of Tide on Staffs.		Remarks.
	h.	min.	ft.	in.			h.	min.	ft.	in.	
1843, July 6. Division 3.	12	0	3	9½			6	0	23	7	
	12	10	3	11¼			6	10	23	3½	
	12	20	4	2	E.		6	20	22	11½	S., strong breeze.
	12	30	4	5½			6	30	22	7	
	12	40	4	10	E. by S.	See Diagram 2. Division 5.	6	40	22	1½	
	12	50	5	3			6	50	21	7½	
	1	0	5	9	E.		7	0	21	0½	
	1	10	6	3			7	10	20	5½	
	1	20	6	9			7	20	19	10½	
	1	30	7	5	N.E.		7	30	19	3	
	1	40	8	1			7	40	18	6¼	
	1	50	8	10½	S.E.		7	50	17	11	
	2	0	9	9			8	0	17	3	
See Diagram 2.	2	10	10	9	S.		8	10	16	6	
	2	20	11	8			8	20	15	10	
	2	30	12	7½			8	30	15	1½	
+	2	40	13	7¼			8	40	14	5½	
	2	50	14	6½	S.S.E., fresh breeze.	See Diagram 2. Division 6. +	8	50	13	9½	
	3	0	15	6			9	0	13	1	S.S.W., strong breeze.
	3	10	16	5½			9	10	12	5	
	3	20	17	3			9	20	11	9	
	3	30	18	2			9	30	11	1	S.W.
	3	40	19	0			9	40	10	4½	
	3	50	19	9			9	50	9	9	
Division 4.	4	0	20	6			10	0	9	1½	
	4	10	21	2			10	10	8	6	
	4	20	21	7½			10	20	7	10½	
	4	30	22	2			10	30	7	3	
	4	40	22	8			10	40	6	7½	
	4	50	23	1			10	50	6	0½	
	5	0	23	5			11	0	5	5½	
	5	5	23	6½			11	10	4	11½	
	5	10	23	8			11	20	4	6½	
	5	15	23	9½			11	30	4	2½	W.S.W., very strong.
	5	20	23	10½			11	40	3	11½	
	5	25	23	10¾	High water.		11	50	3	9½	
+	5	30	23	10¾			11	55	3	9	
	5	35	23	10½		+	12	0	3	8½	
	5	40	23	10¼			12	6	3	9	W.S.W., wind so strong that the observations became incorrect and were discontinued. Watch 2 minutes too slow.
	5	45	23	10							
	5	50	23	9½							
	5	55	23	8½							

End of Observations represented in Diagram 2.

The object being to select Observations as free as possible from disturbances caused by the wind, and where therefore the Tides took their natural course, we will omit the intermediate notes, and pass on to July 10.

1843, July 10.	Greenwich Mean Time. P.M.	Height of Tide on Staffs.	Remarks.
	h. min.	ft. in.	
	12 30	14 3	Calm.
	12 40	13 4	
	12 50	12 5	
+	1 0	11 6	
	1 10	10 8	
	1 20	9 10	
	1 30		
	1 40	8 2½	N.E., slight breeze.
	1 50	7 5¾	
	2 0	6 7½	
	2 10	5 10	
	2 20	5 0½	
	2 30	4 3	N. by E.
	2 40	3 7	
	2 50	3 0	
See Diagram 3. Division 7.	3 0	2 6	
	3 10	1 11½	
	3 20	1 7½	N.E.
	3 30	1 4½	
	3 35	1 3	
	3 40	1 2	
	3 45	1 1	
	3 50	1 0¼	
	3 55	0 11½	
	4 0	0 11	
	4 5	0 10½	N.N.E.
	4 10	0 10	
+	4 15	0 9¾	Low water.
	4 20	0 10	
	4 25	0 10¼	
Division 8.	4 30	0 10½	
	4 35	0 11	
	4 40	0 11¾	
	4 45	1 0½	N., light breeze.
	4 50	1 1¾	
	4 55	1 3	
	5 0	1 4¼	
	5 5	1 5½	N.W.
	5 10	1 7¼	
	5 15	1 9½	
	5 20	1 11½	
	5 25	2 1¾	
	5 30	2 4¼	
	5 40	2 10	
	5 50	3 4¾	
	6 0	4 1	
	6 10	4 10½	N.W.
	6 20	5 8¾	
	6 30	6 7½	
	6 40	7 7½	
	6 50	8 8¾	

	Greenwich Mean Time. P.M.	Height of Tide on Staffs.	Remarks.
	h. min.	ft. in.	
	7 0	9 9½	
	7 10	11 0½	E.
+	7 20	12 4	
	7 30	13 7	
	7 40	14 8½	
	7 50	15 10¼	W., light breeze.
Division 9.	8 0	16 11½	
	8 10	17 10¼	
	8 20	18 10	
	8 30	19 8½	
	8 40	20 6¼	
	8 50	21 3½	
	9 0	21 11½	
	9 10	22 6¾	
	9 20	23 0¾	
	9 30	23 5¼	
	9 35	23 7¾	
	9 40	23 9½	
	9 45	23 11¼	
	9 50	24 0¾	
	9 55	24 1¾	
	10 0	24 2½	
	10 5	24 3	
+	10 10	24 3¼	High water.
	10 15	24 3	
	10 20	24 2½	
	10 25	24 1¾	W., light wind.
	10 30	24 0½	
	10 35	23 11	
	10 40	23 9	W. and by S., light.
	10 50	23 5	
	11 0	23 0	W.N.W.
	11 10	22 6	
Division 10.	11 20	21 11	
	11 30	21 3½	W.N.W., fresh breeze.
	11 40	20 8	Water ceased to be perfectly still.
	11 50	19 10⅓	
July 11,	12 0	19 1	
1843.	12 10	18 3	
A.M.	12 20	17 5	
	12 30	16 7	
	12 40	15 10	
	12 50	15 0	W.N.W., strong breeze.
	1 0	14 2	
See Diagram 2. Division 10.	1 10	13 2	
	1 20	12 4	
	1 30	11 6	
	1 40	10 9	W.N.W., strong breeze.
	1 50	9 11	

Diagrams 2 and 3 show the preceding tide observations projected. The vertical column at the left hand of Diagram 2 is figured in feet to correspond with the feet on the tidestaffs; each of the small vertical divisions represents 2 inches on the staffs.

The horizontal divisions represent the times at which the respective observations were taken, commencing at *5* p. m. on July *5*. Each of the horizontal divisions represents five minutes of time, and the hour of the day or night is indicated by the figures along the bottom horizontal line. The projecting is done in the following manner:—

The height of the water at *5* o'clock being 23 feet 4½ inches, (see observations,) a small dot was first made at that height on the left hand vertical line. Then the height at *5* h. *5* m. being 23 feet 4¾ inches, another small dot was made at that height on the next vertical line, (*i. e. 5* minutes later,) and so on throughout. Afterwards a line was drawn by hand through all these points, viz., the long waving lines on Diagram 2. Diagram 3 was prepared in the same manner.

The extreme point of high water (Diagram 2) being called zero, 1, 2, 3, 4, &c., feet are marked off downwards upon a vertical line from that point as far as mean water. Then the horizontal distances of *time* are measured from such vertical line to the curve of ebb and flow, and written down in *minutes*. And the second column in each of the following tables or "divisions" is a list of them.

	DIVISION 1.					DIVISION 2.			
	Depths measured from high water, downwards, on Diagram 2.	Time elapsed since high water, by observation, also written on Diag. 2. div. 1.	Time calculated by theory of parabola.	Time calculated by formula. C.F. = + 4.8.		Depths measured from high water, downwards, on Diagram 2.	Time elapsed since high water, by observation, also written on Diag. 2. div. 1.	Time calculated by theory of parabola.	Time calculated by formula. C.F. = + 3.
	ft.	min.	min.	min.		ft.	min.	min.	min.
First half of ebb tide.	1	46	46. ▲	49. ▲	Second half of ebb tide.	1	56	56. ▲	56. ▲
	2	67	65.	69.8		2	78	79.2	82.2
	3	86	79.67	89.27		3	97½	97.	103.
	4	104	92.	106.4		4	114½	112.	121.
	5	122	102.8	122.		5	132	125.2	137.2
	6	137	112.67	136.67		6	147½	137.2	152.2
	7	150	121.7	150.5		7	164	148.2	166.2
	8	163	130.	163.6		8	180	158.4	179.4
	9	177	138.	176.4		9	195	168.	192.
	9.10	187½	144.	186.4		9.10	207½	175.6	202.1

Here, assuming (in column 3, division 1) that 46 minutes have elapsed since high water, whilst the tide has fallen 1 foot, which is the fact, and working according to the theory of the parabola, we obtain the respective numbers of minutes given in the third column, which, since they differ very considerably from the numbers of minutes (column 2) by actual observation, *prove that in this case the theory of the parabola is wrong and wholly inapplicable.* But the numbers in column 4 accord very nearly indeed with those of actual observation in column 2, and were calculated by a formula which this agreement therefore proves to be approximately correct. (A in the tables below, signifies that the quantity so marked is assumed to be correct for the purpose of calculation.)

DIVISION 3.				DIVISION 4.			
Depths measured to mean water.	Time by observation.	Parabola.	Calculated by formula. C. F. = +.25.	Depths measured to mean water.	Time by observation.	Parabola.	Calculated by formula. C. F. = +3.4.
ft.	min.	min.	min.	ft.	min.	min.	min.
1	56	56. A	56. A	1	42½	42½. A	42½. A
2	78	79.2	79.45	2	63	60.14	63.54
3	97½	97.	97.5	3	82	73.61	80.41
4	112½	112.	112.75	4	96	85.	95.2
5	127	125.2	126.2	5	109	95.03	108.63
6	139	137.2	138.45	6	122	104.13	121.13
7	149	148.2	149.7	7	132½	112.44	132.84
8	160	158.4	160.15	8	144	120.21	144.01
9	170	168.	170.	9	154	127.5	154.7
10	180	177.	179.25	10	164	134.4	165.
10.1	182	177.8	180.07	10.2	165	135.51	166.69

DIVISION 5.				(UNUSUAL CASE.)—DIVISION 6. Increasing Factor[a].		
Depths measured to mean water.	Time by observation.	Parabola.	Calculated by formula. C.F. = +3.	Depths measured to mean water.	Actual Time.	Parabola.
ft.	min.	min.	min.	ft.	min.	min.
1	53	53. A	53. A	1′	45	45. A V.F.
2	74	74.95	77.95	2	64	63.64 + .36 × 1 = Actual Time.
3	95	91.8	97.8	3	82	77.94 + 2.03 × 2 = Ditto.
4	112	106.	115.	4	97½	90. + 2.5 × 3 = Ditto.
5	128	118.51	130.	5	113	100.62 + 3.09 × 4 = Ditto.
6	142	129.82	144.82	6	130	110.23 + 4. × 5 = Ditto.
7	157½	140.22	158.22	7	145	119. + 4.3 × 6 = Ditto.
8	171	149.91	170.91	8	159	127.28 + 4.53 × 7 = Ditto.
9	187	159.	183.	9	174	135. + 4.87 × 8 = Ditto.
10	201	167.6	194.6	10	189	142.3 + 5.2 × 9 = Ditto.
10.1	202	168.3	195.55	10.1	190	142.9 + 5.2 × 9$\frac{1}{12}$ = Ditto.

SEE DIAGRAM 3.

(UNUSUAL CASE.)—DIVISION 7.				DIVISION 8.			
Depths measured to mean water.	Time by observation. *a*	Parabola. *b*	The differences between columns *a* and *b* = the sums of the factors. These differences are respectively, when divided by their respective depths.	Depths measured to mean water.	Time by observation.	Parabola.	Calculated by formula. F.C. = —1.7
ft.	min.	min.	V.F.	ft.	min.	min.	min.
1	61	61. A	0	1	60	60. A	60. A
2	82	86.27	4.267	2	84	84.85	83.15
3	98	105.65	7.65	3	102	103.92	100.52
4	112	122.	10.	4	114	120.	114.9
5	125	136.4	11.42	5	127	134.16	127.36
6	138	149.42	11.39	6	138	146.97	138.47
7	150	161.39	9.53	7	147	158.75	148.55
8	163	172.53	8.	8	154	169.71	157.81
9	175	183.	5.9	9	165	180.	166.4
10	187	192.9	4.31	10	173	189.74	174.44
11	198	202.31	2.27[b]	11	181	199.	182.
11.9¼	207	209.27		11.9¼	187	205.84	187.54

[a] This is a case where the factor itself increases, as will be observed on noticing the quantities under letter V.F. (See No. 2. p. 9.)

[b] These factors are of the order No. 3. p. 9.

DIVISION 9.				(UNUSUAL CASE.)—DIVISION 10.			
Depths measured to mean water.	Time by observation.	Parabola.	Calculated by formula. C.F. = + 2.2.	Depths measured to mean water.	Time by observation.	Parabola.	By Factor of the order No. 2. p. 9[a].
ft.	min.	min.	min.	ft.	min.	min.	min.
1	43	43. A	43. A	1	44	44. A	44. A
2	64	60.81	63.01	2	64	62.22	63.97
3	80	74.48	78.88	3	80	76.21	80.11
4	93	86.	92.6	4	94	88.	94.39
5	105	96.15	104.95	5	108	98.39	107.95
6	115	105.33	116.33	6	120	107.78	120.18
7	126	113.77	126.97	7	132	116.41	132.31
8	136	121.62	137.02	8	144	124.45	144.26
9	145	129.	146.6	9	157	132.	156.08
10	153	135.98	155.78	10	168	139.14	167.94
11	162	142.61	164.61	11	180	145.93	179.63
11.9¼	168	147.52	171.22	11.9¼	187	150.95	188.73

Of the ten "divisions" of tides, Nos. 6, 7, and 10 do not accord with the formula. It will be seen, however, on reference to the column of observations (pp. 18 and 19) that in numbers 6 and 10 the regularity of the tides has been disturbed by strong winds, so that the non-agreement might have been expected, and we will therefore leave them out of the consideration. I cannot account for the formula being inapplicable to Division 7, there having been little or no disturbance of the water.

The formula, however, is applicable to 7 out of 8 "divisions," and the factors are of order 1, (p. 11,) as will be seen on comparison of columns 2 and 4, in numbers 1, 2, 3, 4, 5, 8, and 9, of the preceding tables respectively.

The *parabola* is inapplicable to all the ten "divisions," as will be seen on inspection. The factors seem to follow no particular law; they are sometimes +, and sometimes −.

The calculations were made precisely in the same manner as those for the curve of spouting fluid at liberty. And of course, therefore, the formula is of the same nature in both cases.

We have now seen that two very dissimilar cases of "fluids in motion," namely, the curve of spouting fluid at liberty, and the curve of ebb and flow of the sea, are not curves of parabolæ. But they are nevertheless governed by a mathematical law, uniform in principle, but requiring to be slightly modified according to circumstances.

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[a] This factor is *increasing*, like the one for Division 6.

SECTION III.

THE CURVE OF INCREASING DISCHARGE OF WATER THROUGH PIPES.

We shall eventually find in this Section that the hydraulic curve of increasing discharge of water through pipes is governed by the same *uniform mathematical law* as the curves of spouting fluid at liberty, and the curves of ebb and flow of the sea.

But before proceeding to this portion of our subject, I propose to test the accuracy of several rules laid down by different authors for the calculation of the quantities of water discharged through pipes. These rules are published in different treatises on hydraulics, and are well known. I shall refer to them more particularly as I proceed. They are all expressed in very different terms, and, as we shall see, all produce different results. It is consequently important to find out if we can whether any, and if so, which may be relied on. Because, though one only can be correct, any one of them is apparently, in the absence of a test, as much to be relied on as another. If our inquiries should chance to confirm one, such confirmation will entitle that rule to a preference proportioned to the value of the evidence I may be enabled to produce. And if it should so chance that I produce reasonable cause for doubting the whole of them, then I shall have made out a case justifying farther inquiry. And I hold it to be a matter of great importance, to ascertain, if I can, whether the treatises on hydraulics give correct rules for calculating the quantity of water discharged through a pipe, under all the infinitely various cases of greater or less *diameter*, *length*, and *pressure*. For where every town in the kingdom has its waterworks, called into existence by the absolute impossibility of supplying the inhabitants by any other means with a sufficiency of this indispensable element, it is, I contend, of the greatest importance to discover what must be the dimensions of pipes under all circumstances, so that they shall just suffice to do the duty required; that they may not on the one hand be too small, or on the other cause a waste of money by being made too large. Any such useless expenditure ultimately falls upon the consumer in the shape of increased charges[a].

I do not propose to enter into any discussion upon the accuracy or inaccuracy of the reasoning of any one of the inventors of formulæ—I will take each rule as laid down by its author, making only occasional remarks where any self-evident objection presents itself. The results will be most readily apprehended by a diagram. See Diagram 4.

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[a] To give some idea of the immense quantities of iron pipes required, I will only mention two facts The Manchester and Salford Waterworks Company have now laid down upwards of 84 miles of iron mains varying from 2½ inches to 2 feet diameter. And in the metropolis alone there are *ten* different and distinct water companies!

MR. SMEATON'S FORMULA.

Mr. Smeaton[a], with a pipe 100 feet long and 1¼ inch diameter, made 16 experiments, each with a different *head* or *column*, varying from 2 inches to 71 inches, which are quoted at length at p. 26. He then projected the results on paper by a scale of equal parts, and drew (by hand I believe) a curve through the points so found, averaging them as well as he could. I have no reason to think this curve, nor any points in it, was produced by calculation. Next,

Having assumed that the discharges so averaged were correct (which doubtless they were approximately) he founded thereon a table for calculating the discharges of pipes of ALL lengths, diameters, and heads. This table was constructed on the *supposition* that the discharges of pipes are directly as the head, inversely as the length, and directly as the diameter.

The theory of the parabola is what Mr. Smeaton here assumed. But this theory is evidently inapplicable to the case; because the calculations made by his rule differ materially from experiments. It was, in the first place, not very scientific to draw the curve entirely by hand and without calculation; and, in the second place, he ought not to have assumed his theory of the parabola to be correct in the absence of all proof. This distinguished man made his designs and calculations for the Eddystone Lighthouse on a surer basis than this; otherwise that admirable piece of engineering would not now have been standing uninjured after so many years' exposure to the tremendous waves and storms it has had to encounter.

For a particular reason, which will appear hereafter, I have made a calculation according to Mr. Smeaton's formula and table[a] for a pipe 60 feet long and 1½ inch diameter, and for the several heads mentioned on the next page.

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[a] Rees's Cyclopædia, article "Water."

TABLE of average velocities in inches per second, with which water ought to flow through a pipe 60 feet long and 1½ inch diameter, according to Mr. Smeaton's rule.

Head. Inches.	Velocity per second. Inches.	Head. Inches.	Velocity per second. Inches.
4.2	4	11.52	24
6.6	5	15.12	28
9.	6	17.16	30
1.2	7	21.66	34
1.62	8	26.88	38
1.92	9	32.82	42
2.34	10	36.	44
3.36	12	39.3	46
4.44	14	42.78	48
5.7	16	48.24	51
7.02	18	54.12	54
8.4	20	60.3	57
9.9	22		

The quantities given in the preceding table are projected in Diagram 4, in the same manner as the experiments on the ebb and flow were projected in Diagrams 2 and 3.

In Diagram 4 the " heads " are written in inches along the vertical lines at the right hand and left hand ends of the graduated part of the paper, and the corresponding velocities are marked off horizontally at their proper places by means of the black perpendicular lines, and the small " scale for velocity in inches per second " at the bottom of the diagram. And then the curve is drawn by hand through the points so found. Mr. Smeaton's curve (Fig. 3) is distinguished by having his name written on it.

M. PRONY'S FORMULA[a].

" Calling U = mean velocity.

Z = head of water in the inferior orifice of the pipe.

L = length of the pipe in metres.

D = diameter of pipe.

We shall have

$$U = -0.0248829 + \sqrt{0.000619 + 717.85 = 7\frac{DZ}{L}}."$$

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[a] See Third Report, British Association, p. 166, where there is a valuable compendium of Hydrostatics and Hydraulics, by George Rennie, Esq., F.R.S.

“ M. Prony has found this formula scarcely differs more or less from experiments than $\frac{1}{40}$ or $\frac{1}{25}$.”[a]

By calculation with this formula for the 60 *feet pipe of* 1½ *inch diameter we have—*

Head. Feet.	Velocity per second. Inches.
1	25.619
2	36.73
3	45.07
4	52.19
5	58.47

By projecting the quantities given in the preceding table, and drawing the curve as before, we obtain the curve of discharge, according to M. Prony's formula—which is marked with his name. See Diagram 4, Fig. 4.

DR. YOUNG'S FORMULA[b].

Dr. Young says, (Phil. Trans. 1808, p. 166,) “ By comparing the experiments which he (Chev. Dubuat) has collected with some of Gerstner and some of my own, I have ultimately discovered a formula which appears to agree, fully as well as Dubuat's, with the experiments from which his rules are deduced; which accords better with Gerstner's experiments; which extends to all the extreme cases with equal accuracy (?); which seems to represent more simply the actual operation of the forces concerned; which is direct in its application to practice, without the necessity of any successive approximation.”

Some of the Doctor's experiments were made with tubes about the $\frac{1}{180}$ of an inch in diameter—about equal to the thickness of a very fine needle! In these experiments, the capillary attraction would be so immense, in proportion to the quantity discharged—and the liability to error in calculating from such minutiæ up to large diameters, would be so great—as to make the experiments, or any inferences capable of being drawn from them, practically of no value.

Dr. Young expresses his formula thus:—

“ Theorem. The mean velocity per second, in inches or v, is $= \sqrt{\left(\frac{d}{a}s + \frac{c^2}{a^2}\right)} - \frac{c}{a}$” d signifies the diameter, or four times the hydraulic mean depth, s represents the sine of inclination, i. e. the head or column of water divided by the length of the pipe. The other symbols used in the theorem are shown at the head of the different columns of the table. He then gives the table, (which is too long to be inserted here,) and afterwards directions how to proceed in making calculations of discharges.

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[a] We shall see by and by that the *difference* is in some cases considerably greater than is here stated. (See p. 45.)

[b] Philosophical Transactions of the Royal Society for 1808, p. 164, &c., and Rees's Cyclopædia, article “ Water.”

By using his formula, &c., as directed, we have for our pipe of 60 *feet long and* 1½ *inch diameter*—

Head. Inches.	Discharge per minute. Cubic feet.
6	1.143
12	1.691
18	2.114
24	2.469
30	2.784
35	3.010
40	3.234
45	3.443
50	3.638
55	3.825
60	4.004

Note.—In any given case, the discharge in cubic feet per minute, and the average velocity in inches per second, are convertible terms. For in this case 10 inches velocity per second are equal to about .612 cubic feet per minute. And for convenience, the diagram has two scales, one for inches velocity per second, and the other for cubic feet per minute, each equal in effect to the other. By projecting Dr. Young's discharges given above, and proceeding as before, we obtain the curve for 60 feet pipe marked with his name. See Diagram 4, Fig. 5[a].

CHEVALIER DUBUAT.

The writer of the article "Waterworks," in the Encyclopædia Britannica, details the method pursued by the Chevalier Dubuat, in collecting and dealing with facts in order to procure the necessary data from which to deduce a formula. He says—

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[a] The discharging end of the pipe does not appear to have been filled, (Vol. 2, Trans. Civil Engineers, p. 203, &c.,) where the "head" was less than 20 inches, so that the average velocity must have been in point of fact greater than the scale appears to make it with these heads. But still the scale for velocity is a correct measure of the quantity discharged; being constructed on the evidently correct principle of dividing the quantity discharged in a given time by the cross sectional area of the pipe.

"The Chevalier Dubuat has collected a prodigious number of facts, comprehending almost every case of the motion of fluids. He first classed them according to their resemblance in some one particular, and observed their differences in other circumstances; and by considering what could produce these differences, he obtained general rules, deduced from fact, by which these differences could be made to fall into a regular series. He then arranged all the experiments under some other circumstances of resemblance, and pursued the same method; and by following this out, he has produced a general proposition, which applies to the whole of this numerous list of experiments with a precision far exceeding our utmost hopes." (?)

The writer then observes that "there is a very large class of these experiments which is not direct." He next mentions what the class consists of. "Two large cisterns were made to communicate with each other by means of a pipe. The surfaces of the water in these cisterns were made to differ only by a small fraction of an inch, and it is supposed that the motion in the communicating pipe will be the same as in a very long pipe, or an open canal, having this very minute declivity. We have no difficulty in admitting the conclusion, but we have seen it contested, and it is by no means intuitive."

A little further on he says, "We need not have any hesitation in the adoption of the Chevalier Dubuat's general proposition, because the experiments which we are now criticising fall in precisely with the general train of the rest, and show no general deviation which would indicate a fallacy in principle."

Notwithstanding this recommendation, "not to have any hesitation in the adoption of the Chevalier Dubuat's general proposition," I think the apparatus of the two cisterns, communicating by a pipe, is liable to some objections. If this "minute fraction of an inch" is to be an invariable and constant quantity—*its effect will of course be invariable and constant also.* Consequently the arrangement can only be analogous to a *particular case* of a very long pipe—the actual and precise length of which we have still to ascertain. Because if this pipe had its length increased by (say) 100 feet, its discharge would evidently be diminished by reason of *increased* friction. Or by cutting off 100 feet from its length, the discharge would of course be increased by reason of *diminished* friction; and this, although it were (and properly so) still termed a "very long pipe." So that the proposition as it stands at present, is vague and indefinite. But even if we help out the hypothesis of the cisterns, by assuming that this difference of a "minute fraction of an inch" represents correctly the discharge of a pipe of a particular length; and that a *little diminution* of that *difference* of the surfaces represents correctly the effect of a certain increased length of pipe, and so forth—which may be and possibly is true—yet still we are no nearer. For supposing the difference of the surfaces of the water to be $\frac{1}{10}$ *inch*—how are we to know WHAT *length* of pipe *that* represents?

or WHAT *other length* of pipe is represented by a difference of, say, $\frac{1}{8}$ inch? In short, what have we to guide us in referring any differences of surfaces to any particular lengths of pipe? It is clear we should be under the necessity of instituting actual experiments to determine these points. And if we were to make actual experiments,—the necessity for the arrangement of the "cisterns" would of course be superseded!

He then gives two tables, occupying each nearly a quarto page filled with very small figures, too long to be quoted here, "which with great labour have been computed for this work." (The Encyclopædia Britannica, "Waterworks," pp. 786, 787.)

These tables are respectively headed—

"Table 1. Logarithms of the values of the numerator of the fraction,

$$\frac{307\sqrt{(d-0.1)}}{\sqrt{s} - L\sqrt{s+1.6}}$$ for every value of the hydraulic mean depth d.

Also the value of $0.3\ (\sqrt{d}-0.1)$."

"Table 2. Logarithms of the values of the denominator of the fraction,

$$\frac{307\ (\sqrt{d}-0.1)}{\sqrt{s}-L\sqrt{s+1.6}}$$ for every value of the slope s."

We gather that $d=\frac{1}{4}$ of diameter of pipe, giving for our pipe of $1\frac{1}{2}$ inch diameter, $d=.375$ and Log. of $307\ (\sqrt{d\ .375}-0.1)=2.196722$.

Note.—This is more correct than following the directions, (given in Example 1, p. 788,) and taking proportional parts.

However, taking proportional parts as directed, we obtain Log. 2.19461. $s=$ length of pipe divided by the head.

Following the rules given and the tables, I have calculated the following table, both for Log. 2.196722 and Log. 2.19461. On making the calculations both ways, the difference between the two results was found to be very trifling; but having calculated them, I may as well insert both.

Calculation by Chevalier Dubuat's formula, of the velocity with which water ought to flow through a pipe of 60 *feet long and* $1\frac{1}{2}$ *inch diameter.*

Head. Inches.	Velocity in inches per second. By Log. 2.19461	By Log. 2.19672
6	18.302	18.391
12	27.53	27.664
18	35.098	35.269
24	41.732	41.935

Head. Inches.	Velocity in inches per second.	
	By Log.	By Log.
30	47.768	48.
36	53.315	53.575
42	58.513	58.798
48	63.425	63.734
54	68.123	68.455
60	72.504	72.857

These results being substantially the same, only one of them is projected on Diagram 4, and is marked with the author's name, "Dubuat."

M. EYTELWEIN'S FORMULA.

This gentleman published in 1801, at Berlin, "a valuable compendium of hydraulics, entitled '*Handbuch der Mechanik und der Hydraulik*,' which contains an account of many new and valuable experiments made by himself. In treating of the motion of water in pipes, he obtains the following simple formula, which *agrees wonderfully with experiment*, (*?*)

" $$V=50\surd\left(\frac{dh}{l+50\,d}\right)$$

in which l is the length of the pipe, d the hydraulic mean depth, and h the height of the reservoir."[a]

Here $d=.03125$ ft. ($=.375$ inch) $h=1$, 2, 3, 4, 5 ft. respectively, and $l=60$ ft., and V signifying the velocity, we have

Head. Feet.	Velocity per second. Inches.
1	13.416
2	18.97
3	23.4
4	27.
5	30.18

These velocities when projected are found to be so very much less than the least of the results of the previous formulæ, that at first it was apprehended there must have been some error in the calculations. But they have been found correct on going over them again. M. Eytelwein's formula, therefore, gives a much smaller result than any of the previous ones. See Diagram 4, Fig. 2.

Since this paper was finished, the following has been found in "Tracts on Hydraulics," p. 205:—

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[a] Encyclopædia Britannica, "Hydrodynamics," p. 6.

"To determine the velocity of discharge of a pipe when the height of the water in the reservoir above the point of discharge, and the length and diameter of the pipe are given.

"Rule. Multiply 2500 times the diameter of the pipe in feet by the height in feet, and divide the product by the length in feet, added to 50 times the diameter, then the square root of the quotient will be the velocity of discharge in feet per second."

By this rule we obtain—

Head. Feet.	Velocity in inches per second.	
1	26.0628	Pipe 60 feet long and 1½ inch diameter.
2	36.856	
3	45.141	
4	52.125	
5	58.277	

These quantities are projected, as usual, in Diagram 4, see Fig 4, and are nearly the same as those given by M. Prony's formula, at p. 65.

Dr. Young and I have been using the same formula of M. Eytelwein—but it appears we make the results widely different from each other. This is owing to his understanding the symbol d in M. Eytelwein's formula $V = 50\sqrt{\left(\frac{d\,h}{l+50\,d}\right)}$ to signify the *diameter*, whilst I understand it to mean the *hydraulic mean depth, or one fourth of the diameter* of the pipe. My authority is, as before quoted, Encyclopædia Britannica, "Hydrodynamics," p. 6, where d is stated to signify "hydraulic mean depth." This difference of opinion could only be settled by reference to M. Eytelwein's original work in German; but I have it not at hand, nor is that material, as I have made the calculations in both ways as just given—and both results are also shown in Diagram 4.[a]

M. GENIEYS.

In 1829, a work in quarto, entitled, "Essai sur les Moyens de conduire, d'élever et de distribuer les Eaux, par M. Genieys, Ingénieur au Corps Royal des Ponts et Chaussées attaché au service de la Distribution des Eaux dans Paris,"—was published at Paris.

At page 39 in his work, he says: "Nous allons indiquer une methode pour trouver directement cette formule dans le cas du mouvement permanent de l'eau dans le tuyaux à section uniforme, qui nous a été communiquée par M. Belanger."

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[a] I have, since this essay was in type, referred to M. Eytelwein's original work in German; and have found that d signifies *the diameter*, consequently the writer in the Encyclopædia Britannica has (unintentionally of course) mis-stated M. Eytelwein's formula.

He then, by means of a diagram referred to, explains with great minuteness M. Belanger's view of the modus operandi of the forces concerned in the flow of water through pipes, and expresses what he estimates to be the value of each of these forces, in algebraic terms; but as he offers no proofs, his views can only be considered theoretical, however ingenious they may be. These details, which are too long to be quoted at full length (they occupy about three quarto pages) include an account of what M. Prony has done to determine that the value of

The constant number a is $= 0.00017$
Ditto b is $= 0.003416$

from a mean " entre cinquante et une expériences faites sur les tuyaux de conduite, par Couplet, Bossut et Dubuat.

" On a donc l'équation générale

$$\text{``}\; 0.00017\,\nu + 0.003416\,\nu^2 = \tfrac{1}{4}\,D\,g\,\frac{\zeta - H' + H}{\lambda}$$

" et divisant tous les termes par $g = \overset{\text{m.}}{9}.808795$.

$$\text{``}\; 0.0000173314\,\nu + 0.0003482590\,\nu^2 = \tfrac{1}{4}\,D\,\frac{\zeta - H + H}{\lambda}$$

" dans laquelle on peut faire, pour abréger,

$$\frac{\zeta - H' + H}{\lambda} = j$$

$$0.0000173314 = \alpha$$

$$0.0003482590 = \beta$$

" ce qui donne l'équation connue

$$\alpha\,\nu + \beta\,\nu^2 = \tfrac{1}{4}\,D\,j.\text{''}$$

Afterwards follows a table (p. 43, &c.) by means of which and the formula referred to I have obtained, for the discharge of our pipe of 60 *feet long and* $1\frac{1}{2}$ *inch diameter, the following quantities here given in English inches.*

Head. Feet.	Velocity per second. English inches.
6	32.227
12	46.038
18	56.397
24	65.604
30	73.277
36	80.183
42	86.705
48	92.46
54	98.598
60	103.585

These quantities projected appear to exceed the greatest of any of the four first formulæ about as much as M. Eytelwein's fall short of the least. See Diagram 4, Fig. 7.

Each of these six formulæ has doubtless been considered by its author, and by others, to fulfil satisfactorily that highly important desideratum in practical science—*a rule for calculating the discharges of straight pipes in all cases.* This may be gathered from the confident expressions quoted, with which each formula is brought forward.

These formulæ appear for the most part to be founded chiefly on some hypothesis with respect to the mode in which the water is acted on in passing through the pipe. Attempts are made by means of abstract reasoning to apprehend and explain the precise motion of the water, as also to estimate the separate nature and amount of each of the forces concerned in producing or retarding its flow. Thus gravity, friction, viscidity, &c., are each attempted to be estimated in actual value, either by means of abstract reasoning, or by means of what are supposed to be analogous experiments, or both. Now this would be a very good thing, provided it were possible to do it; but it seems to me impossible. I confess I cannot comprehend how these forces could be practically analysed so as to determine with certainty the precise value of each. We have seen how each inventor of a formula differs from all the others in practical results, in despite of much acute reasoning and many elaborate and careful experiments and calculations. The formulæ all produce materially different results the one from the other; and we shall also see, in the course of a few more pages, that ALL these results differ materially from facts. In the exercise of my humble judgment, I have pursued a course quite different from that of my predecessors. I have addressed myself directly to the facts ascertained by actual experiments, combining—as those facts of course do—ALL the forces actually and simultaneously concerned in producing or retarding the flow of water. I have attempted no analysis, but have endeavoured, not without success, to adapt formulæ which shall accord with and obey the aggregate laws—respectively developed by each set of experiments.

It will now be my duty to test the general accuracy of the six formulæ as far as that accuracy can be tested by an individual case. For this purpose, I shall institute a comparison with some very accurate experiments, made with a pipe of the same dimensions as the one I have been speaking of, namely, 60 feet long and $1\frac{1}{2}$ inch diameter. Here, since "comparisons are" proverbially "odious," I must be permitted to say one word in explanation. My sole object is to inquire, as far as I can, whether any, and if so, *which* of these rules is to be relied on. And this question naturally arises from the fact of their all differing from each other, as shown by the preceding calculations, and the graphic projections of those calculations marked with the names of the several inventors in Diagram 4. And I humbly take leave to think that this is a legitimate and not an invidious object of inquiry. In science, facts only (not individuals) are matter of interest. The science of hydraulics has at various times engaged the attention of some of the most eminent philosophers of Italy, Germany, France, and England, and it is still an object of great interest to scientific men of all nations; and I feel quite certain, therefore, that my inquiries will be attributed to their proper and sole motive, namely, *scientific research. It is necessary for the purposes of science that truth should be ascertained.*

If my humble opinion could be of any moment, I would say of all my predecessors in this inquiry, that their ingenuity, skill, and perseverance, have enabled them to collect a number of valuable experiments, from which they have deduced approximate formulæ, in some cases surprisingly correct, when we consider the imperfect and insufficient materials at their disposal; and their exertions will ever connect their names honourably with the science of hydraulics· I will therefore institute the comparison I have mentioned without any further hesitation.

EXPERIMENTS ON THE FLOW OF WATER THROUGH SMALL PIPES (1½ INCH DIAM.)

By W. A. PROVIS, M. Inst. C. E[a].

This is the title prefixed to the paper communicating the results of a very valuable series of experiments.

Mr. Provis first gives a description of the apparatus employed, and of the several duties of himself and his three assistants. Of his apparatus and arrangements I shall say no more, than that I think they were well adapted for making the experiments in a satisfactory manner.

Omitting a few experiments with a pipe of 100 feet, for the present I will confine myself to a brief account of the several experiments with pipes of the respective lengths of 80, 60, 40, and 20 feet, and all of the diameter 1½ inch.

These experiments were made with each of the four pipes in four different methods. A description of the four classes of experiments for one particular pipe, will serve as a description for all the four pipes, and therefore, as I have been for some time considering the discharges of a particular sort of pipe, viz., a pipe of 60 feet in length and 1½ inch diameter, I will describe Mr. Provis's experiments with that pipe. The results are given in cubic feet per minute.

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[a] Transactions of the Institution of Civil Engineers, Vol. II. p. 201, &c.

Mr. Provis first had his 60-feet pipe laid *level*, and one end of it inserted into a cask, in which in the first two experiments the water stood at a constant height of 35 inches; for the second two experiments at the constant height of 30 inches; and so on, by which he found that—

	Inches.		Cubic feet per minute.
A constant head of	35	discharged at the farther end	2.891 2.857
Ditto	30	Ditto	2.608 2.58
Ditto	24	Ditto	2.308 2.296
Ditto	18	Ditto	1.951 1.967
Ditto	12	Ditto	1.548 1.568
Ditto	6	Ditto	1.048 1.057

the experiments being always made in duplicate.

These experiments are projected in Diagram 4, Fig. 8, and are there distinguished by a small dot within a circle, thus, ⊙.

The *second class* of experiments was made with the same pipe, the only difference being that the pipe was laid with *an inclination in the ratio of* 1 *in* 112, equal in the whole length of a 60-feet pipe to the head of 6.428 inches additional [a].

In this class he had the water kept at the same constant heights in the cask as in the case of class 1, but the water had in each case the additional velocity caused by a vertical height of 6.428 inches in the declivity of the pipe, added to 35.30 inches, &c., height of water in the cask as before. This class of experiments will therefore stand thus:—

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[a] As every person may not feel disposed to give immediate assent to the *propriety of treating the fall in the pipe as so much additional head*, I will say a few words on the subject presently. And it will also perhaps not be unworthy the attention of those who *do assent* to the proposition, to see a strong confirmation of it.

	Inclination of pipe. Inches.		Head of water in cask. Inches.		Total head. Inches.	Discharge in cubic feet per minute.
Marked thus × in Diagram 4, Fig. 8.	6.428	+	35	=	41.428	3.117 3.137
	6.428	+	30	=	36.428	2.891 2.891
	6.428	+	24	=	30.428	2.637 2.637
	6.428	+	18	=	24.428	2.33 2.318
	6.428	+	12	=	18.428	1.967 1.983
	6.428	+	6	=	12.428	1.6 1.6

The *third class* was made by giving the pipe an inclination in the ratio of 1 *to* 56, equal in the whole length of a 60-feet pipe to 12.857 inches. And the water being kept at the same constant heights in the cask as before, we have—

	Inclination of pipe. Inches.		Head of water in cask. Inches.		Total head. Inches.	Discharge in cubic feet per minute.
Marked thus ⊡ in Diagram 4, Fig. 8.	12.857	+	35	=	47.857	3.38 3.38
	12.857	+	30	=	42.857	3.2 3.243
	12.857	+	24	=	36.857	2.927 2.927
	12.857	+	18	=	30.857	2.637 2.637
	12.857	+	12	=	24.857	2.33 2.353
	12.857	+	6	=	18.857	2.017 2.

The *fourth class* was made by giving the pipe an inclination in the ratio of 1 in 37.33, equal in the whole length of a 60-feet pipe to 19.28 inches. And the water being kept at the same constant heights in the cask as before, we have—

	Inclination of pipe. Inches.		Head of water in cask. Inches.		Total head. Inches.	Discharge in cubic feet per minute.
Marked thus + in Diagram 4, Fig. 8.	19.28	+	35	=	54.28	3.636 3.636
	19.28	+	30	=	49.28	3.428 3.428
	19.28	+	24	=	43.28	3.2 3.2
	19.28	+	18	=	37.28	2.944 2.944
	19.28	+	12	=	31.28	2.696 2.666
	19.28	+	6	=	25.28	2.376 2.388

The next step was to project these experiments, which has accordingly been done in Diagram 4, by taking the vertical divisions at each end as so many inches head according to the figures; and the horizontal divisions as so many cubic feet per minute, according to the upright figures along the top and bottom horizontal lines of the diagram.

Of course the scale for inches velocity per second, the *divisions for velocity per second*, and *discharge in cubic feet per minute*, are made *exactly equivalent* oneto the other [a].

The discharges are projected, (of course each horizontally from its proper head,) and are distinguished by the respective marks ⊙ × ⊡ and +, the central parts of these signs being always the correct points.

Where the duplicate experiments agreed precisely, that fact is indicated by a small figure 2 near the sign.

When all the preceding discharges had been projected, the black line marked "60 feet TRUE DISCHARGE," was drawn (we will suppose for the present by hand) through the centres of the several groups of marks ⊙ ⊡ + and ×, and this line of course gives the *true discharge of our* 60-*feet pipe;* that is, with an accuracy exactly proportioned to the accuracy of the experiments. I have before asserted that these experiments were "very accurate." And I consider this very satisfactorily proved by the *positions in which they arrange themselves*, and their *near agreement one with another*. They also prove the correctness of the principle of treating the *vertical amount of inclination* in the pipe as *so much additional head*, (see note at p. 36) for the following reasons:

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[a] See note at p. 28.

See the group of 8 experiments, a little below "60 feet" on the black line. (Fig. 8, Diagram 4.) Here the two experiments marked ⊙ ⊙ are on the horizontal line of 24 inches head. The two next above, marked × ×, will be found on examination to have been made with the pipe having an inclination of 1 in 112, giving a vertical height of 6.428 inches + (18 inches, actual head of water in the cask,) together equal to a head of 24.428 inches, and giving a little greater discharge than a head of 24 inches, as it ought to do, if the theory of considering the vertical amount of inclination in the pipe as so much additional head be correct.

The third pair of experiments in this group, marked ⊡⊡, will be found on examination to have been made with the pipe having an inclination of 1 in 56, giving a vertical height of 12.857 inches + (12 inches, actual head of water in the cask,) together equal to a head of 24.857 inches; and this gives a little greater discharge than the head of 24.428 inches, as my theory requires.

The fourth pair of experiments, marked + +, consists of an inclination in the pipe of 19.28 inches (1 in 37.33), added to 6 inches head = 25.28 inches head; and this again discharges a little more than a head of 24.857, as by the theory it ought.

And, again, if we compare by the eye, which the diagram gives us facility for doing, the general tendency in direction of the groups, we shall see that they indicate a curve, which an average line drawn through each group separately falls in and accords with (Diagram 4, Fig. 8.)

And similar results will on examination be found to obtain throughout; *proving at once the approximate accuracy of the experiments, and the correctness of the principle of considering the vertical amount of inclination in the pipe as so much additional head.*

COMPARISON OF THE SIX FORMULÆ WITH EXPERIMENT.

On looking at the diagram, one cannot help being struck with the following facts:—

1st. How nearly the experiments are a mean of the two extreme formulæ, namely, those of M. Eytelwein and M. Genieys.

2nd. How nearly the experiments are a mean of the two next formulæ, namely, those of Mr. Smeaton and Chevalier Dubuat.

3rd. How very nearly the experiments are a mean of the two most accurate formulæ, namely those of M. Prony and Dr. Young.

I think no scientific man will, after satisfying himself that my calculations are correctly made from M. Eytelwein's and M. Genieys' directions, make use of either of these gentlemen's formulæ.

Mr. Smeaton and Chevalier Dubuat, though nearly correct with small "heads," diverge farther and farther from the truth as the "head" increases, so that it is apparent, by the time we arrive at a "head" of 15 or 20 feet, their formulæ will have ceased to be approximations at all.

M. Prony is more nearly correct, but it is apparent that his formula also diverges farther and farther from the truth, (though not to so great an extent as the formulæ of Mr. Smeaton and Chevalier Dubuat,) so that by the time we come to a head of perhaps 50 or 60 feet, his formula will have ceased to be an approximation to fact.

Head. Inches.	Discharge per minute by Dr. Young's formula. Cubic feet.	Average discharge per minute by Mr. Provis's experiments. Cubic feet.	Dr. Young's formula in excess per cent.
6	1.143	1.048	9.
12	1.691	1.559	8.4
18	2.114	1.960	7.8
24	2.469	2.304	7.1
30	2.784	2.610	6.6
35	3.010	2.846	5.7
40	3.234	3.067	5.4
45	3.443	3.277	5.
50	3.638	3.477	4.6
55	3.825	3.668	4.2
60	4.004	3.852	3.9

The table just given shows to what extent and in what manner Dr. Young's formula differs from fact. With a head of 6 inches, *Dr. Young's formula gives too great a discharge* by 9 per cent. This excess diminishes pretty regularly, until we come to the "head" 60 inches, where the discharge is only 3.9 per cent. too great. By projecting the per centages, and drawing a line, we find that with a head of about 8½ feet, the *formula would agree with the* experiments. With a head of 17 feet, the experiment would be greater than the formula by about 10 per cent. With a head of 25 or 26 feet, the formula would be about 20 per cent. in arrear. And so on—the formula diverging constantly 10 per cent. more from fact by the addition of each 8 or 9 feet of head. I place a good deal of reliance on this mode of testing Dr. Young's formula, as a tolerable approximation, though it *is* merely mechanical. I shall, however, apply another test presently.

THE ACCOUNT OF MR. PROVIS'S EXPERIMENTS, CONTINUED.

Mr. Provis had for his 80-feet pipe, four classes of experiments, the same as for the "60-feet," namely:—

Class 1,	pipe laid *level.*		
,, 2,	pipe inclined in ratio of		1 in 112.
,, 3,		ditto	1 in 56.
,, 4,		ditto	1 in 37.33.

He had also these four classes for the 40-feet pipe, and the same for the 20-feet pipe.

All the discharges obtained by experiments with these pipes have projected in Diagram 4, (Figs. 9, 10, 11,) precisely in the same way I projected the discharges for the 60-feet pipe. The full black curve lines respectively represent the average discharges of these pipes, which lines have each the length of its pipe written upon it. And I wish to call particular attention to the fact, that each curve line does actually pass through the centres of its own several groups of experiments; thereby coinciding nearly with and averaging any mass of experiments that accord nearly with each other, and paying little attention to those experiments which stand alone. And this, I take leave to think, is a much better method of obtaining an average than taking only the mean of two or three experiments.

I have hitherto been considering the black curve lines, (Diag. 4, Figs. 8, 9, 10, and 11,) as though they had been drawn by hand entirely. This is not the fact, however. *The black dots are all points found by calculation*, and any greater number of points in the curve could of course have been determined by calculation, had it been necessary. For example, a point at the crossing of each of the horizontal lines might have been calculated so as to settle every part of the curve with the greatest possible accuracy. But the effect of every additional inch of head having been ascertained, it is presumed the calculations have been carried out with a sufficient regard to minuteness of detail. It will now be my business to explain the *new method of calculating the discharges through pipes.*

MR. PROVIS'S FOUR PIPES.

I have just said that the black dots on the diagram are points found by calculation.

The calculutions for the discharges of the 60-feet pipe, 1½ inch diameter, with various heads, are made in the following manner:—

The experiments when projected (see the marks ⊙ + ⊡ ×, Diagram 4, Fig. 8) are carefully examined, and *one actual discharge* is fixed upon by the eye, and the scale of equal parts, (generally, for convenience of calculation, with a head of an *even* number of inches,) and this *actual discharge is assumed to be correct for the purposes of calculation.*

In this case the head fixed upon was 24 inches, and its discharge is taken at 2.304 cubic feet per minute, which it is as nearly as I can judge. Then the rule is, (supposing the discharge with 25 inches head is required)—

EXAMPLE I.

Inches head.

$\sqrt{24} : 2.304 :: \sqrt{25} : 2.3515$

ADD Factor (C.F.) . . .0058 × 1 because the required discharge is for 1 inch greater head than discharge assumed.

True discharge by formula 2.3573

EXAMPLE II.

Let it be required to calculate the discharge of the same pipe with a head of 40 inches.

Then $\sqrt{24} : 2.304 :: \sqrt{40} : 2.9745$

And the head sought being *greater* than the head assumed, we must again *add* the Factor, which is found in the following manner:—

From the head *sought*, viz. . 40
Deduct the head assumed, viz. 24

Difference . . 16 which × .0058 = .0928 total co-efficient.
To which add . . . . . 2.9745 calculated as above.

True discharge by formula as before 3.0673 for 40 inches head.

EXAMPLE III.

Let it be required to calculate the discharge with a head of 60 inches.

Then $\sqrt{24} : 2.304 :: \sqrt{60} : 3.6429$

Difference between head
assumed and head sought is 60
−24

=36 × .0058 = .2088 (*added* as before)

3.8517 = discharge with 60 inches head required.

Thus we *add* to the result of the first operation, as many times .0058 as the head sought *exceeds in inches* the head assumed.

But we *deduct* from the result of the first operation, as many times .0058 as the head sought is *less in inches* than the head assumed. Thus,

EXAMPLE IV.

Let the discharge with a head of 12 inches be required.

Then $\sqrt{24} : 2.304 :: \sqrt{12} : 1.6291$

From . 24
Take . 12

Remains 12 which × .0058 = .0696 *deducted*

1.5595 = discharge with 12 inches head.

EXAMPLE V.

Let the discharge sought be with 6 inches head.

Then $\sqrt{24} : 2.304 :: \sqrt{6} : 1.152$

From 24
Take 6

Remains 18 which × .0058 = .1044 *deducted*

1.0476 discharge with 6 inches head.

The operation may be extended to larger heads—ad infinitum.

These results agree with Diagram 4, Fig. 8, and table at p. 151.

The results of these calculations, which are given at p. 60 and 61, (corresponding with Figs. 8, 9, 10, 11, Diagram 4,) as I have before said, represent the discharges of the pipes with an accuracy proportioned to the accuracy of the experiments themselves; and if I were required to estimate the accuracy of the experiments, I would say that—

With the 80-feet pipe the experiments are *satisfactory*.
„ 60 „ *very satisfactory*.
„ 40 and 20 „ *tolerably satisfactory*[a].

In proportion to this estimate I assume that these calculations would be approximately correct, if carried out up to a head of 100 feet or more for the 60-feet pipe, and I consider it right to assume this; because we know that no new force can or does enter into the case of discharge of water through pipes after Mr. Provis's experiments have ceased. [It is self-evident also that the *forces*, such as friction, viscidity, resistance of air, &c., which affect these discharges, *if they alter at all*, can only alter (and that *gradually*) *in degree* of intensity. None of them can cease entirely.] And since our formula *ascertains* and *obeys* the law of nature as far as the experiments extend, (subject as that law is to the aggregate of these several resistances,) we have a right to assume that the formula will obey that law *ad infinitum*, with an accuracy proportioned to the accuracy of the experiments. And I do assume so accordingly.

It is now clear that these curves of discharge of pipes (of increasing head), the curve of spouting fluid, and the curve of ebb and flow of the sea, consist each of ordinates of parabolæ, added to arithmetically increasing co-efficients; consequently, all these three, though they are cases of fluids in motion under such very dissimilar circumstances, are yet governed by a simple and uniform mathematical law.

PROBABLE CONSEQUENCES OF USING THE BEST OF THE SIX FORMULÆ, CONSIDERED IN A COMMERCIAL POINT OF VIEW.

We will therefore treat our formula, deduced from and adapted to Mr. Provis's experiments, as producing a *standard velocity* for the several heads of 40, 60, and 100 feet, and 1½ inch pipe of 60-feet length, and calculate the velocities by the formulæ of M. Prony and Dr. Young.

---

[a] I trust to be pardoned for the free use made of Mr. Provis's valuable experiments, and for expressing an opinion that he deserves great credit for his ingenuity, perseverance, and love of science. It must be a difficult thing to obtain *correct* discharges with *short lengths* and *large heads*.

Average velocity in inches per second with which water will flow through a pipe 60 feet in length and 1½ inch diameter:—

Head. Feet.	Average Velocities. Prony.	Young.	Formula deduced from Provis's Experiments.
40	163	191	373
60	200	235	480
100	258	304	666

Here we see that neither M. Prony's formula, nor that of Dr. Young, give even an approximation to the truth. Neither of their formulæ give as much as half of the true velocities. With the head of 100 feet Dr. Young's formula gives only about $\frac{5}{11}$ of the standard deduced from Mr. Provis's experiments.

I will now inquire a little more particularly into the consequences of an engineer relying upon any, even the best of the six formulæ. And for that purpose shall, in the first instance, give a table of diameters, areas, and weights of cast-iron pipes.

Table of the Weight of Iron Pipes cast at Carron Iron Works in 1769, being their standard for dried Sand Castings, allowing every 36 cubic inches of Cast Iron to be equal to 10 lbs.[a]

Diameter of the Pipe.	Full Diameter of the Flanch.		Length of Pipe.	Thickness of Pipe.	Weight of Pipe.			Area of Section of Pipe.
Inches.	Ft.	In.	Feet.		Cwt.	qrs.	lbs.	Inches.
2		8	6	$\frac{3}{8}$	0	2	10	3.14
2½		8½	6	$\frac{7}{16}$	0	3	4	4.9
3		9	6	$\frac{1}{2}$	1	0	10	7.07
3½		9½	6	$\frac{1}{2}$	1	0	27	9.62
4		11	6	$\frac{1}{2}$	1	1	18	12.57
5	1	0	6	$\frac{1}{2}$	1	2	18	19.63
6	1	2	8	$\frac{5}{8}$	3	1	21	28.27
7	1	3	8	$\frac{5}{8}$	3	3	20	38.48
8	1	5	9	$\frac{3}{4}$	6	0	10	50.27
9	1	6	9	$\frac{3}{4}$	6	3	4	63.62
10	1	7	9	$\frac{3}{4}$	7	1	22	78.54
11	1	9	9	$\frac{7}{8}$	9	2	17	95.03
12	1	10	9	$\frac{7}{8}$	10	1	12	113.1
13	1	11	9	$\frac{7}{8}$	11	0	26	132.73
14	2	0	9	$\frac{7}{8}$	11	2	7	153.94

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[a] The whole of this table is copied from Rees's Cyclopædia, article "Water," with the exception of the column of areas, which has been added. The date is ancient, and flanch joints, now in a great measure superseded by socket joints, are contemplated in this Table. But those circumstances do not affect the calculations.

Now let it be supposed that an iron pipe is to be laid where the nature of the ground is such that there is a column or head of 100 feet vertical pressing on the lower end of the pipe, which is by no means an unusual amount of pressure. It will be seen, by referring to the small table at p. 45 in this paper, that Dr. Young's formula, which is the best of the six tested, gives less than half the true discharge with a pipe of 1½ inch diameter. Now, if this formula is in error, with a small pipe, it is not likely that it will be correct with a large one. On the contrary, we see by the table, (p. 45,) that his formula with a head of 40 feet gives only about half the true discharge; whilst with a head of 100 feet it only gives $\frac{5}{11}$ of true discharge. Therefore, the inaccuracy increases as the head increases.

I know of no reason why Dr. Young's formula can be supposed more accurate with large pipes and large heads, than it is with small pipes and large heads. On the contrary, it seems reasonable to suppose that the greater the quantities to be dealt with, the greater the chance of error. However, we will take the comparative velocities for a 1½ inch pipe, (p. 45,) as an average of the comparative velocities by Dr. Young's formula and by experiment with heads of 100 feet, and for pipes of all diameters; for the purpose of giving a general idea of the useless expenditure likely to be incurred by the use of an incorrect formula.

And therefore if I were to make a calculation for the discharge of a main pipe to convey water to supply a town according to Dr. Young's formula, I should obtain only $\frac{5}{11}$ of the true discharge. From which it follows I should be induced to lay down a pipe with $\frac{6}{11}$ greater sectional area than would suffice for the quantity of water I had previously ascertained was to be conveyed. For example, (referring to the column of areas in the preceding table,) I should be induced to use

A 5 inch pipe where a 3½ inch would suffice.
7 ditto 5 ditto.
10 ditto 7 ditto.
14 ditto 10 ditto.

From which is to be deduced, by means of the other data given in the preceding table, and taking the price of iron at £10 per ton, the following account of useless expenditure incurred by the use of an incorrect formula :—

A 5-inch pipe will cost, per mile,	£730
3½ ditto	546
Loss per mile by using an incorrect formula	£184 or 25 per cent.

A 7-inch pipe will cost per mile	£1296	
5-inch as before	730	
Loss per mile by using an incorrect formula	£566	or 43 per cent.

A 10-inch pipe will cost per mile	£2184	
7 ditto as above	1296	
Loss per mile by using an incorrect formula	£888	or 40 per cent.

A 14-inch pipe will cost per mile	£3391	
10 ditto as above	2184	
Loss per mile by using an incorrect formula	£1207	or 35 per cent [a].

This, be it remembered, is the loss consequent on using the *best* of the formulæ. But it is of course very unlikely that any person could hit upon the *best one* out of *six*, where there is nothing to guide his choice. And the loss would, therefore, stand a chance of being much greater.

Such is the state of this very important branch of hydraulics in the middle of the nineteenth century!

DISCUSSION OF MR. PROVIS'S AND OF SOME OTHER EXPERIMENTS ON THE FLOW OF WATER THROUGH PIPES.

The average results of Mr. Provis's experiments, calculated by the new formula, see p. 60, 61 (and graphically represented by the curve lines, Figs. 8, 9, 10, 11, in Diag. 4,) are treated in another manner in Diag. 5.

The horizontal divisions still signify the discharges in cubic feet per minute. The vertical divisions represent the lengths of pipe, and the curve lines represent the discharges with a *constant head* of 10 inches, 15 inches, &c., and with various lengths of pipe. In fact, the diagram shows the effect produced in *diminishing the discharge* by *increasing the length* of the pipe.

I have adapted a formula for the 10-inches head, with which the following results have been obtained:—

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[a] See Appendix, p. 62, 63.

Length of Pipe. Feet.	Actual discharges taken from Diag. 4, and Table at p. 60. Cubic ft. per min.	By formula B.
20	2.284	2.284 assumed.
40	1.721	1.721 assumed.
60	1.406	1.4052 *calculated.*
80	1.202	1.217 *calculated.*

Formula B is (Log. $\sqrt{20}$ + Log. .0276) : 2.284 :: square root of any other length of pipe (not exceeding 100 feet,) to its discharge.

The same formula is also modified for a 15-*inch head.*

Length. Feet.	Discharge from Diag. 4, and Table at p. 60, &c. Cubic ft. per min.	By formula C.
20	2.869	2.869 assumed.
40	2.173	2.173 assumed.
60	1.769	1.774 *calculated.*
80	1.520	1.536 *calculated.*

Formula C is (Log. $\sqrt{20}$ + Log. .0298442) : 2.869 :: square root of any other length of pipe (not exceeding 100 feet,) to its discharge, nearly. On examination of these two little tables, it will be seen that the two last quantities in each table agree very nearly with the true discharges.

A slight modification of either of these formulæ would also give in like manner the discharges of the same pipes with the respective heads of 11, 12, 13, and 14 inches.

It is plain, then, that by the invention of formulæ as here explained, we may get at the discharges of greater lengths of pipe than those actually experimented on. But a little consideration will also show that it is *essential,* in fact quite *indispensable,* that the experiments should be taken with the *greatest possible accuracy.* For it is evident that if there be only a slight error in the experiments with which we have just been dealing, (or any others,) by adapting the formulæ to that error, and calculating onwards up to greater lengths of pipe, the discharges obtained must deviate more and more from the truth, until at some limit the calculated discharges would cease to be approximations at all. Now, on examining the experiments on Diag. 4, we at once perceive that the signs ⊙ × ⊡ and + for the 20 and 40-feet pipes, (particularly the former,) are scattered over too wide a space of paper. They have not been made with *sufficient precision to justify us in adopting them as a basis for an extended calculation.*

I suspected that if I adapted a formula *to greater heads*, as 40 inches, 35 inches, the calculated discharges would not agree with the experiments, and the following results show that the suspicion was correct.

HEAD, 40 INCHES.

Length. Feet.	Actual discharges taken from Diag. 4, in cubic feet per minute.	By formula.
80	2.645	2.645 assumed.
60	3.067	3.067 assumed.
40	3.798	3.756 *calculated.*
20	4.995	5.312 *calculated.*

HEAD, 35 INCHES.

Length. Feet.	Discharge from Diag. 4.	By formula.
80	2.454	2.454 assumed.
60	2.846	2.846 assumed.
40	3.521	3.4856 *calculated.*
20	4.635	4.9294 *calculated.*

These results are anomalous. Having adapted our formula to the 80 and 60 feet lengths, the quantity produced by the calculation for the 40-feet pipe is too little, whilst the quantities for the 20-feet pipe are considerably too great in both cases.

The *discharges* with Mr. Provis's 60-feet pipe (which I have adopted as a test for the six formulæ, because those discharges were most nearly correct,) excepted, no other series of his experiments are in my opinion sufficiently correct to form a basis for very extended calculations. Therefore, all I could do has been to draw curves mechanically in Diagram 5, which give the approximate discharges for intermediate lengths of pipes. If all his experiments had been as correct as those with his 60-feet pipe, some analogy, some *definite proportion,* would have been discoverable between the respective discharges of the 80, 60, 40, and 20 feet pipes. No blame ought to be attached to Mr. Provis, however. It is a difficult thing to make the experiments with precision.

The formula for the calculated velocities in Table 1 following, is—from log. 2.56804242 take the log. of the square root of the length of pipe of which the velocity is required, and the remainder will be the log. of the velocity sought.

Note.—This formula is precisely of the same nature as the usual one, the deduction of the co-efficient being comprised within the constant number, log. 2.56804242.

The formula for Table 2 is $\sqrt{31.97}$: 51.723[a] :: the square root of any other length to its ordinate of parabola.

From this ordinate of parabola deduct .387 for each 32 feet additional length beyond the original 31.97 feet, (and a proportionate quantity for each smaller or larger additional length,) and the remainder will be the velocity sought.

Note.—In all cases of comparing the calculations by formula with the experiments, it ought to be remembered that the *differences* are not wholly attributable to error in the formula, because the experiments themselves contain slight errors. And since the formula *averages the experiments en masse,* it is reasonable to believe that sometimes the calculations are more nearly correct than the experiments themselves.

In Table 3, singularly enough, the velocities obey the law of the parabola; no factor is required!

In Table 4 the factor is — .3 deducted arithmetically as before.

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[a] The experiments having some inaccuracies in them, as appeared by internal evidence, it was attempted to get rid as much as possible of those errors by altering a little the one of the actual velocities which is assumed for the purpose of calculation; and it appears that some quantity, a trifle less (say about .2 less) than 51.723 was assumed to calculate with. This precise quantity has by accident not been noted. But if 51.723 is assumed, the quantities will come out very nearly as in the table.

Abbé Bossut's Experiments adjusted and extended by the new Formula. (See *post.*)

Lengths of Pipe.	TABLE 1.		TABLE 2.		TABLE 3.		TABLE 4.	
	Head of Water 25.5768 * Inches.				Head of Water 12.7884 * Inches.			
	Diam. of Pipe 2.14 * Ins.		Diam. 1.4209 * Inches.		Diam. 2.14 * Inches.		Diam. 1.4209 * Inches.	
Feet.	Actual Velocity.	Calculated Velocity.	Actual Velocity.	Calculated Velocity.	Actual Velocity.	Calculated Velocity.	Actual Velocity.	Calculated Velocity.
*31.97	*62.773	65.414	*51.723	50.765	*42.971	42.971 A	*35.338	35.038
35.		62.518		49.398		41.073		33.747
40.		58.481		46.154		38.416		31.526
45.		55.136		43.464		36.22		29.683
50.		52.306		41.185		34.36		28.122
55.		49.873		39.222		32.761		26.777
60.		47.75		37.508		31.367		25.603
*63.94	*45.825	46.254	*36.738	36.30	*31.135	30.385	*24.895	24.775
65.		45.876		35.994		30.136		24.565
70.		44.207		34.644		29.04		23.64
75.		42.708		33.43		28.055		22.808
80.		41.352		32.33		27.165		22.054
85.		40.118		31.328		26.353		21.367
90.		38.987		30.409		25.611		20.737
*95.913	*38.12	37.766	*29.92	29.415	*25.37	24.81	*20.187	20.055
100.		36.987		28.836		24.296		19.621
105.		36.095		28.053		23.711		19.121
110.		35.265		27.375		23.166		18.656
115.		34.49		26.741		22.656		18.221
120.		33.764		27.147		22.18		17.813
125.		33.081		25.589		21.732		17.43
*127.88	*32.926	32.706	*25.581	25.28	*22.067	21.485	*17.188	17.219
130		32.44		25.062		21.31		17.068
135		31.833		24.57		20.911		16.726
140		31.26		24.091		20.534		16.402
145		30.715		23.644		20.177		16.095
150		30.199		23.26		19.839		15.803
155		29.708		22.814		19.516		15.525
*159.85	*29.275	29.254	*22.414	22.439	*19.5	19.217	*14.99	15.267
160.		29.24		22.427		19.208		15.26
165.		28.794		22.058		18.915		15.06
170.		28.367		21.705		18.635		14.763
175.		27.959		21.367		18.366		14.531
180.		27.568		21.043		18.11		14.307
185.		27.193		20.732		17.863		14.093
190.		26.833		20.432		17.627		13.887
*191.83	*26.35	26.704	*20.14	20.325	*17.456	17.543	*13.38	13.814
195.		26.486		20.144		17.399		13.689
200.		26.153		19.868		17.18		13.498
210.		25.523		19.34		16.766		13.136
220.		24.936		18.85		16.38		12.798
230.		24.388		18.39		16.021		12 482
240.		23.874		17.958		15.683		12.185
250.		23.392		17.553		15.366		11.905
260.		22.938		17.169		15.068		11.641
270.		22.51		16.807		14.786		11.391
280.		22.103		16.463		14.52		11.154
290.		21.72		16.136		14.267		10.929
300.		21.354		15.825		14.028		10.715

The quantities obtained by reducing Abbé Bossut's experiments from French into English measures are distinguished by the mark *.

A signifies that the quantity so marked is assumed.

The following are some particulars of the experiments which have been treated in the foregoing four tables.

From the Cyclop. Brit., (article "River," p. 269,) we find the Abbé Bossut made a series of 24 experiments, numbered there 59 to 82 inclusive, which I have divided into 4 classes.

	Diam. of Pipe. French Inches.	Head of Water. French Inches.	The Nos. in Cyclop. Brit. of the experiments included in each class.
Class No. 1	2.01	24	59, 60, 62, 63, 65, and 66.
,, 2	1⅓	24	71, 72, 74, 75, 77, and 78.
,, 3	2.01	12	73, 76, 79, 80, 81, and 82.
,, 4	1⅓	12	61, 64, 67, 68, 69, and 70.

In each of these series he made the experiments with horizontal pipes of the several lengths 30, 60, 90, 120, 150, and 180 French feet, which (taking the French inch = 1.0657 English inch,) are equal to the respective lengths 31.97, 63.94, 95.913, 127.88, 159.85, and 191.83 English feet, as given in the tables. And,

French Inches.		English Inches.
2.01	being equal to	2.14
1⅓	ditto	1.4209
12	ditto	12.7884
24	ditto	25.5768

we obtain the several quantities given at the heading of the preceding tables. And the velocities ascertained by the Abbé are also reduced into English inches, and given in the table.

The next step was to invent a formula as simple and uncomplicated as possible, which would obey the law developed by the experiments, and enable us to *ascertain the respective velocities in* GREATER *and* INTERMEDIATE *lengths of pipe without having recourse to further experiments.* These formulæ have been already described.

The formulæ agree very well with experiment, as will be seen by comparison of the "actual velocities," in column 2, Table 1 (p. 51), with the corresponding "calculated velocities" in column 3. Where though the difference between experiment and calculation varies from 1¾ inches to ½ an inch velocity per second for the lengths of pipe from 32 to 64 feet, yet in the remaining lengths from 64 to 192 feet, the variance between calculation and experiment never amounts to so much as ½ an inch per second.

It would be useless to invent a formula more precisely adapted than this, unless we were assured the experiments themselves are absolutely free from errors. But there is a degree of anomaly about them which induces me to believe they do contain slight errors. If these were not made in duplicate, that circumstance justifies my doubt of their precise accuracy; and if they were made in duplicate, it is much to be regretted that the result of each separate experiment has not been given in Mr. Provis's manner. For we should then have had the means of appreciating their accuracy by the near agreement, (or the contrary,) and should have been enabled to average them by means of the formula as in Diag. 4.

The following is a comparative list of velocities by observation, and by the formula used for Table 2.

Length of Pipe. Feet.	Actual velocity in inches per second.	Calculated velocity in inches per second.
31.97	51.723	50.765
63.94	36.738	36.30
95.913	29.92	29.415
127.88	25.581	25.28
159.85	22.414	22.439
191.83	20.14	20.325

Here the difference between the actual and calculated velocities in no case amounts to one inch per second. And in four cases it is less than *half an inch* per second.

I have now shown that a formula can be adapted to the *increasing length* of pipes as well as to the *increasing head*, and have given a list of the approximate velocities for a number of intermediate lengths, besides those actually experimented with, as well as for other lengths greater than any used in the experiments.

By making use of the formulæ I have given, any person may extend the calculations. I think it is likely they might be carried out to a length of pipe of 1500 feet at least, without any considerable inaccuracy.

Experiments were made at Versailles, by M. Couplet, with a pipe 5 French inches diameter, (=5.3258 English inches,) and with six several heads equivalent to 26.642, 25.577, 22.468, 17.85, 12.078, and 5.95 English inches respectively, and length 84240 French inches = 7481.21 English feet[a].

Head. English inches.	Observed velocities. Inches per second.	Calculated velocities. Inches per second. C.F. = .0558 +
[b] *5.95	*2.14	2.14 A[c]
10.		3.00
*12.078	*3.36	3.39
15.		3.90
*17.85	*4.40	4.37
20.		4.71
*22.468	*5.12	5.08
25.		5.45
*25.577	*5.56	5.53
*26.642	*5.67	5.68
30.		6.15
35.		6.81
40.		7.45

The column of calculated velocities is obtained by the formula with the addition of the ordinary factor of the nature of No. 1, at p. 9, and applied in the usual manner.

Here again it is to be regretted that the experiments were not repeated again and again, until the velocities were well settled, and ALL *the results published.*

If other experiments could have been taken in the same manner, and with *greater heads,* and several other shorter lengths, they would have been especially valuable on account of the diameter of the pipe, which is greater than the diameter of the pipes usually experimented with. If the experiments had been made and published as above stated, and on a more extended scale, that is to say, with other "heads," of say, 40, 60, and 100 inches, there is no reasonable cause to doubt that a formula might have been adapted to this pipe of M. Couplet's, by means of which the velocity of the water could have been *calculated correctly for any head of water whatever*

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[a] See Cyclop. Brit. "River," p. 269, experiments 83, 84, 85, 86, 87, and 88.

[b] The quantities reduced from French to English measure have a star prefixed.

[c] A signifies that the quantity so marked is *assumed* to be correct.

Experiments were made by the Chevalier Dubuat[a], with a pipe 1 French inch diameter, with 8 different "heads," some of the experiments being made in duplicate. Their equivalents in English measures are subjoined, and the formula adapted; the calculated velocities are given in a separate column. The length of the pipe was 65.45 English feet.

Head. Inches.	Velocity by experiment. Inches per second.	Velocity by calculation. C.F.=.209+
[b]*.16	*1.6934	1.3817
*.533	*3.8611	2.5218
*4.476	*11.372 *11.127	11.25 A
5.		11.961
*6.3196	*14.19	13.752
*8.29	*16.105	16.107
*9.55	*17.717 *17.354	17.493
10.		17.97
12.79		20.754
*13.13	*21.304	21.076
*14.6	*22.348	22.434
15.		22.793
*15.56	*23.292	23.291
20.		27.024
*25.257	*30.552	31.066
*25.58		31.304
30.		34.459
35.		37.838
40.		41.555
45.		44.14
50.		47.115
55.		49.994
60.		52.793
65.		55.52
70.		58.183
75.		60.79
80.		63.345
85.		65.854
90.		68.32
95.		70.747
100.		73.139

Here the formula has an arithmetically increasing factor, which is applied as usual.

The following are Mr. Smeaton's experiments, already mentioned at p. 25, on which he founded his formula. They were made with a pipe 100 feet in length and $1\frac{1}{4}$-inch diameter.

Head. Inches.	Observed velocity. Inches per second.	Calculated velocity by formula. Inches per second. C.F.=+.0788
2.	6.5	6.5 A
2.8	7.75	7.751
3.8	8.75	9.101
4.8	10.	10.290
5.0		10.514
6.2	11.5	11.775
7.8	13.4	13.293
10.		15.164
10.7	15.5	15.72
13.		17.419

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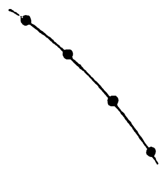
[a] Cyclop. Brit., "River," p. 269, experiments 44 to 53 inclusive, also 55 and 56.

[b] The quantities reduced from French to English measure have a star prefixed.

Head. Inches.	Observed velocity. Inches per second.	Calculated velocity by formula. Inches per second. C. F. = +.0788
14.5	18.25	18.487
15.		18.825
18.1	21.	20.8
20.		21.973
23.	23.75	23.698
25.		24.793
27.6	27.	26.163
30.		27.38
30.5	28.25	27.629
34.3	29.75	29.463
35.		29.791
35.6	30.25	30.072
40.		32.063
45.		34.22
47.	35.5	35.056
50.		36.282
55.		38.262
60.		40.172
65.		42.02
70.		43.812
71.	43.75	44.165
75.		45.556
80.		47.256
85.		48.915
90.		50 537
95.		52.126
100.		53.684

The preceding experiments of Mr. Smeaton's are copied from Rees's Cyclopædia, article “Water;” the edition I use not being paged, I cannot give the page.

I have projected the experiments, and there is an irregularity in their direction which indicates some little inaccuracy. It is impossible, by means of mathematical or algebraic series, to follow them exactly. The experiments with “heads” of between 27 and 48 inches stand at some little distance to the *right* of the full curve *line*[a], whilst a single experiment at the top of the diagram, namely, with a head of 71 inches, falls to the *left* hand of the same curve line. The remaining experiments with less “heads” stand *some to the right* and *some to the left.* And the existence of a general law is only indicated by the mass at large to which I have adapted a formula. And the results of such formula do not differ materially from any of the experiments, as may be seen by comparison in the previous table, and also in Diagram 4, Figure 1, where the experiments are denoted by the centre of the mark ⊙, and points found by the formula are distinguished by small black dots, through which the hydraulic curve is drawn by hand, thus—



It is stated[b] of Mr. Smeaton, “we believe he arranged them (the experiments) into the table, by projecting and drawing a curve, at least we find that was his usual method in like cases." Then follows a table, in which one of the columns of figures gives Mr. Smeaton's averages of his own experiments, which are shown in the diagram by a dotted line. The points found by projecting Mr. Smeaton's averages of his own experiments, are indicated by the apex of the mark Λ, and the dotted line is drawn from point to point by hand, curving it a little between. This line proves to be irregular, and we think it very probable he projected his experiments to a small scale, and in consequence read some of the results off a little incorrect; and so when they are projected on a large scale, (as in this case,) they do not resolve themselves into a regular curve. If this was so, it was not a very scientific method of dealing with them. And with great humility, I submit that my method is preferable, because it agrees about as well as his with the experiments, and as it depends on a mathematical law, the calculation may be continued to any extent at pleasure. I think it intuitive that the forces in operation, in the case of water flowing through pipes, would give results which, when projected in the way we have been describing, would produce a *regular* curve. That is, supposing the experiments to be entirely and absolutely correct; for there could be no *sudden* increase or diminution to produce irregularity.

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[a] Diagram 4, Fig. 1.

[b] Rees's Cyclopædia, article “Water.”

Because, since water will flow with the smallest appreciable declivity, it follows that every minute addition to the "head" would accelerate the discharge of water in a small degree, and thus *gradually* increase the velocity according to some uniform law of nature, and this would of *necessity* cause the curve to be *regular*.

Dr. Young[a] gives some more experiments by Dubuat, Gerstner, and himself, with very small pipes, varying from .2575 to .0058 English inch diameter, and of lengths varying from 1¼ to 67 English inches. These pipes are so small, that I am of opinion no useful results can be obtained from the experiments made with them.

BORES OF PIPES.

Chevalier Dubuat's 24 experiments, discussed a few pages back, having been made with heads of 25.5768 and 12.7884 English inches respectively, I have selected from the calculated tables given in connexion with those experiments, the velocities with a length of pipe of 65.45 English feet, which was the length of the pipe used by the same gentleman in a set of his experiments subsequently discussed. I have also calculated the velocities for other pipes of the *same length* with the two *above-named* "*heads*," and as many different diameters as I could obtain. Subjoined is a table of the velocities and diameters so found:—

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[a] Phil. Trans. 1808.

TABLE of velocities in inches per second with which water will flow through pipes 65.45 feet long, with the respective heads 25.58 and 12.79 inches.

Diameter of pipe. Inches.	With a head of 25.58 Inches.		With a head of 12.79 Inches.	
	Velocity observed.	Velocity calculated. C.F. = +1 inch *velocity* for each additional inch diameter.	Velocity observed.	Velocity calculated. C.F. = +1.2 inch *velocity* for each additional inch diameter.
1.0657	*31.304 A		*20.754	20.754 A
1.42	[a]36.33	36.68	*24.4	24.382
1.5	*37.4	37.57		25.143
1.75		40.8		27.416
2.		43.81		29.553
2.14	*45.7	45.43	*30.75	30.7
2.5		49.38		33.509
3.		54.456		37.142
3.5		59.16		40.532
4.		63.58		43.729
4.5		67.76		46.768
5.		71.74		49.675
5.5		75.55		52.469
6.		79.21		55.165

Note.—The quantities with a * prefixed have been obtained from the tables previously given.

It will be observed that in the preceding tables, having obtained the velocities with four pipes, with a uniform *length* and *head*, and different diameters, I have adapted a formula by means of which the calculation has been extended to pipes of 10 other different diameters, namely, up to the diameter of 6 inches.

The formula and the manner of using it are as usual.

Diagram 6 shows the quantities in these last tables isometrically projected. Fig. 1 refers to the pipe with the smaller "head," and fig. 2 to the pipe with the greater "head." The points marked with a small circle, thus, ⊙, indicate the quantities obtained by averaging former experiments by the formula, and the black dots indicate the points now found by farther calculation.

Note.—The quantities agree so nearly with experiment, that in two cases the black dot is *within* the small circle, showing in those cases that the results of experiments and calculation are *nearly identical.*

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[a] This quantity is obtained by projecting and drawing a curve.

It has now been proved—

1st. That formulæ may be adapted to the curve of spouting fluid at liberty, by means of which such curve can be continued.

2nd. That formulæ may be adapted to the curve of ebb and flow of the sea, by means of which, and of certain data specified, such curve may also be calculated.

3rd. That formulæ of the same nature may be adapted to the hydraulic curve of increasing discharge of water through pipes, with constant lengths and diameters, but *increasing heads*, and the curve can be continued *ad infinitum*.

4th. That formulæ may be adapted to the hydraulic curve of decreasing discharge of water through pipes of uniform diameters and heads, but *increasing lengths*, and the curve can be continued *ad infinitum*.

5th. That formulæ may be adapted to the hydraulic curve of increasing discharge of water through pipes of uniform lengths and heads, but *increasing diameters*[a], and the curve can be continued *ad infinitum*.

6th. All these formulæ being of the same nature precisely, with a very few exceptions, which have been specified, and which are too few to affect the question of the prevalence of a general rule:

7th. It follows, that a *uniform mathematical law* governs the five preceding cases of "fluids in motion;" which is what I undertook to prove in a practical manner.

At another time I propose to resume this subject.

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[a] See propositions at pp. 2 and 3.

Average discharges of pipes of $1\frac{1}{2}$ inch diameter, and of the respective lengths of 20, 40, 60, and 80 feet, deduced *by formula* from W. A. Provis's experiments, and which are graphically represented by Figs. 8, 9, 10, and 11, Diagram 4[a].

Head. Inches.	20-feet Pipe. Discharge in cubic feet per minute. C.F.=.0145.	40-feet Pipe. Discharge in cubic feet per minute. C.F. = .0089.	60-feet Pipe. Discharge in cubic feet per minute. C.F.=.0058, see p. 42, &c.	80-feet Pipe. Discharge in cubic feet per minute. C.F.=.003765.
1.			.337	
2.			.537	
3.			.693	
4.			.825	
5.			.942	
6.	1.711	1.277	1.048	.887
7.	1.867	1.398	1.145	.971
8.	2.014	1.512	1.237	1.054
9.	2.152	1.619	1.324	1.130
10.	2.284 A	1.721	1.406	1.202
11.	2.409	1.818	1.485	1.271
12.	2.531	1.912	1.559	1.337
12.79		1.983		
13.	2.647	2.002	1.632	1.399
14.	2.76	2.089	1.702	1.461
15.	2.869	2.173	1.769	1.520
16.	2.976	2.254	1.835	1.578
17.	3.079	2.333	1.898	1.633
18.	3.180	2.411	1.960	1.687
19.	3.278	2.486	2.021	1.739
20.	3.375	2.560 A	2.080	1.791
21.	3.469	2.632	2.138	1.841
22.	3.562	2.703	2.194	1.891
23.	3.652	2.772	2.249	1.938
24.	3.741	2.84	2.304 A	1.986
25.	3.828	2.907	2.357	2.031
25.58		2.945		
26.	3.915	2.972	2.410	2.077
27.	3.999	3.036	2.461	2.122
28.	4.083	3.1	2.512	2.166
29.	4.164	3.163	2.562	2.209
30.	4.246	3.224	2.61	2.251
31.	4.325	3.285	2.659	2.293
32.	4.405	3.345	2.706	2.334
33.	4.482	3.404	2.754	2.375
34.	4.559	3.463	2.8	2.415
35.	4.635	3.521	2.846	2.454
36.	4.711	3.577	2.891	2.493
37.	4.784	3.633	2.936	2.532
38.	4.858	3.689	2.98	2.57
39.	4.930	3.744	3.024	2.608
40.	4.995	3.798	3.067	2.645
41.		3.852	3.11	2.682

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[a] By means of the formula this Table may be continued up to any "head" whatever, *ad infinitum*.

Head. Inches.	20-feet Pipe. Discharge in cubic feet per minute. C.F.=.0145.	40-feet Pipe. Discharge in cubic feet per minute. C.F.=.0089.	60-feet Pipe. Discharge in cubic feet per minute C.F.=0058,see p.42,&c.	80-feet Pipe. Discharge in cubic feet per minute. C.F.=.003765.
42.		3.906	3.152	2.718
43.		3.959	3.194	2.754
44.		4.011	3.236	2.790 A
45.		4.063	3.277	2.825
46.		4.113	3.318	2.861
47.		4.164	3.357	2.894
48.		4.215	3.397	2.929
49.			3.437	2.963
50.			3.477	2.997
51.			3.516	3.03
52.			3.553	3.063
53.			3.592	3.096
54.			3.63	3.129
55.			3.668	3.160
56.			3.705	
57.			3.742	
58.			3.779	
59.			3.816	
60.			3.852	

The quantities to which letter A is affixed, were respectively *assumed* for the purposes of calculation.

APPENDIX.

It will, I think, not be out of place, if I quote here a few passages from "The First Report of the Health of Towns Commission." The passages quoted prove, by inference, that the subject of the foregoing essay is of great practical importance to the poor.

> 5552. * * "It is also proved that if the system of keeping on water constantly at a high pressure be adopted * * * water may be distributed into every room of such a house[a] from the general reservoir or filter at an expense not exceeding 1½*d.* per week."

An apparatus for the removal of impurities is then mentioned, and other arrangements for applying the water to the general purposes of health and cleanliness. The question is then put,—

> "Now supposing these several desiderata accomplished, the cesspools removed, abundant supplies of pure water carried up to the tops of the houses to every floor, and, if required, into every room, and ventilation made effectual—can you form any opinion as to the extent to which sickness and mortality might be reduced by these several arrangements?"

To which J. Toynbee, Esq., F.R.S., one of the surgeons of the Westminster Dispensary, the gentleman then under examination, answers—

> "It is difficult to form any estimate, but I feel confident of a reduction of one-third. It is my opinion that the diseases which are produced secondarily, and which have hitherto been supposed to have no connexion with the causes specified, would be influenced or prevented to a very great extent. The habit of drinking, stimulated, if not produced, by nervous depression, would be abated—the diseases which are rendered more fatal and are modified by the habit, would be diminished. From what I have seen, I am disposed to expect that very beneficial effects would arise from the influence on the general spirits, the relief from the depression giving greater spirit and energy to them. I am disposed to believe, on a careful consideration of all

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[a] Cottages of the humblest and most unhealthy description are meant.

the effects producible by such alterations, that a reduction of one-half the existing amount of sickness and mortality might be produced by them."

The gentleman is asked—

"5553. If an increased rental were requisite for these improvements, instead of there being generally reductions of existing charges, and if they were to fall as new charges upon occupants, such as those whom you have alluded to, do you believe they would defray them cheerfully?"

"I have no doubt of it. Having been informed of the practicability of laying on pure water constantly at a penny a week, I have asked a great number of the patients, whether they would consent to pay an additional rent of twopence a week to have the water laid on in their rooms, and they have expressed warmly their willingness to pay even more; that such payment would be but a trifle for such a 'blessing,' as they have termed it."

Mr. Thomas Cubitt, in his examination, says—

"249. The expense of a water company consists not so much in what may be called their plant, that is, their buildings and pumping machinery, as the capital required for carrying their pipes everywhere. These companies have many hundred miles of pipes, and it is there that much of their capital is locked up."

This is notorious to those practically acquainted with the construction of water-works.

Why should these poor people be taxed to the amount of even a penny per week, if the "blessing" could be afforded them cheaper? It has been shown, that if the laws of hydraulics were well understood, the useless expenditure of much money might be spared to the proprietors of waterworks, who would then be able to afford a supply of water to poor people at a much less price.

Slyne Lodge, near Lancaster,
April, 1845.

Diag

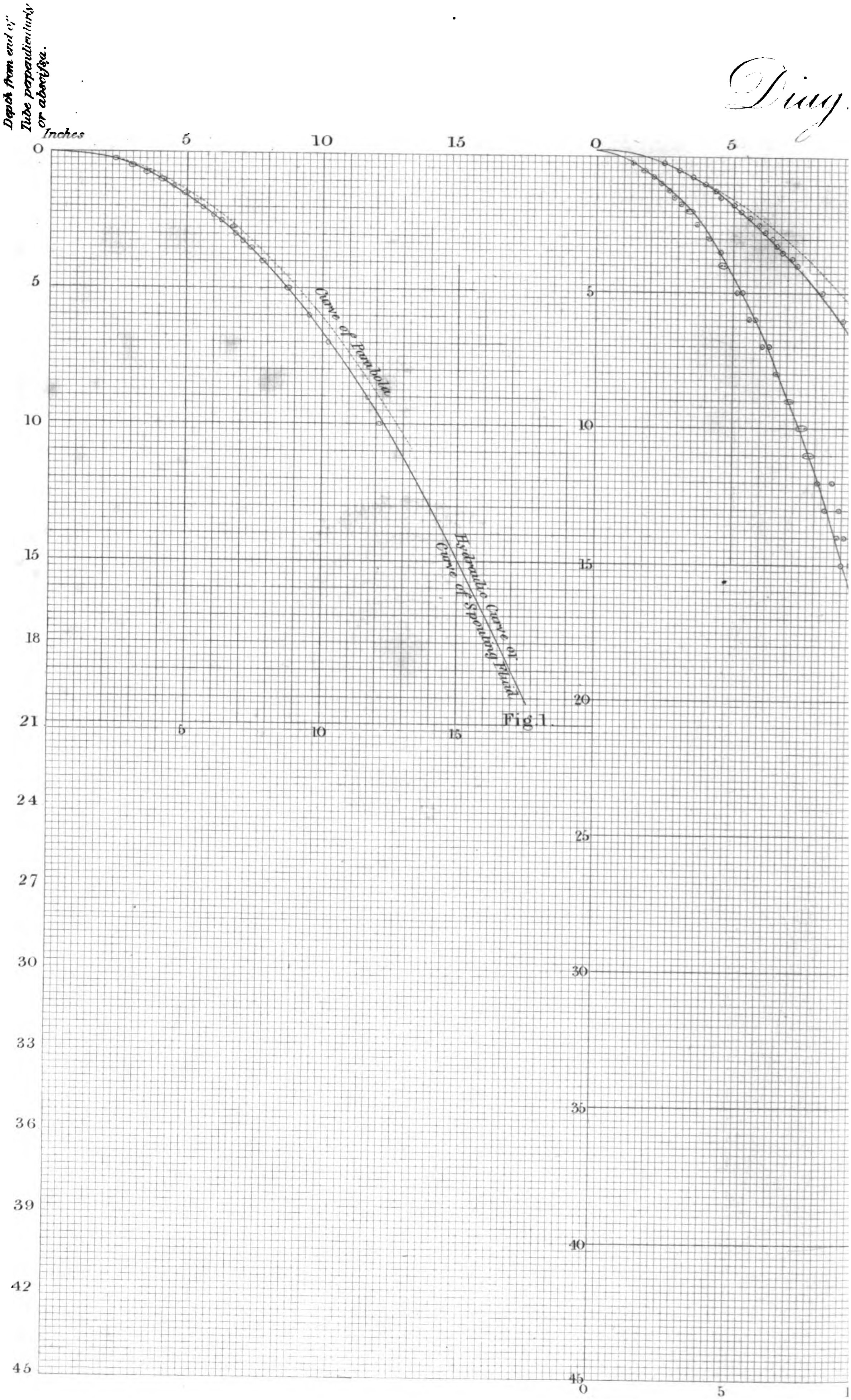
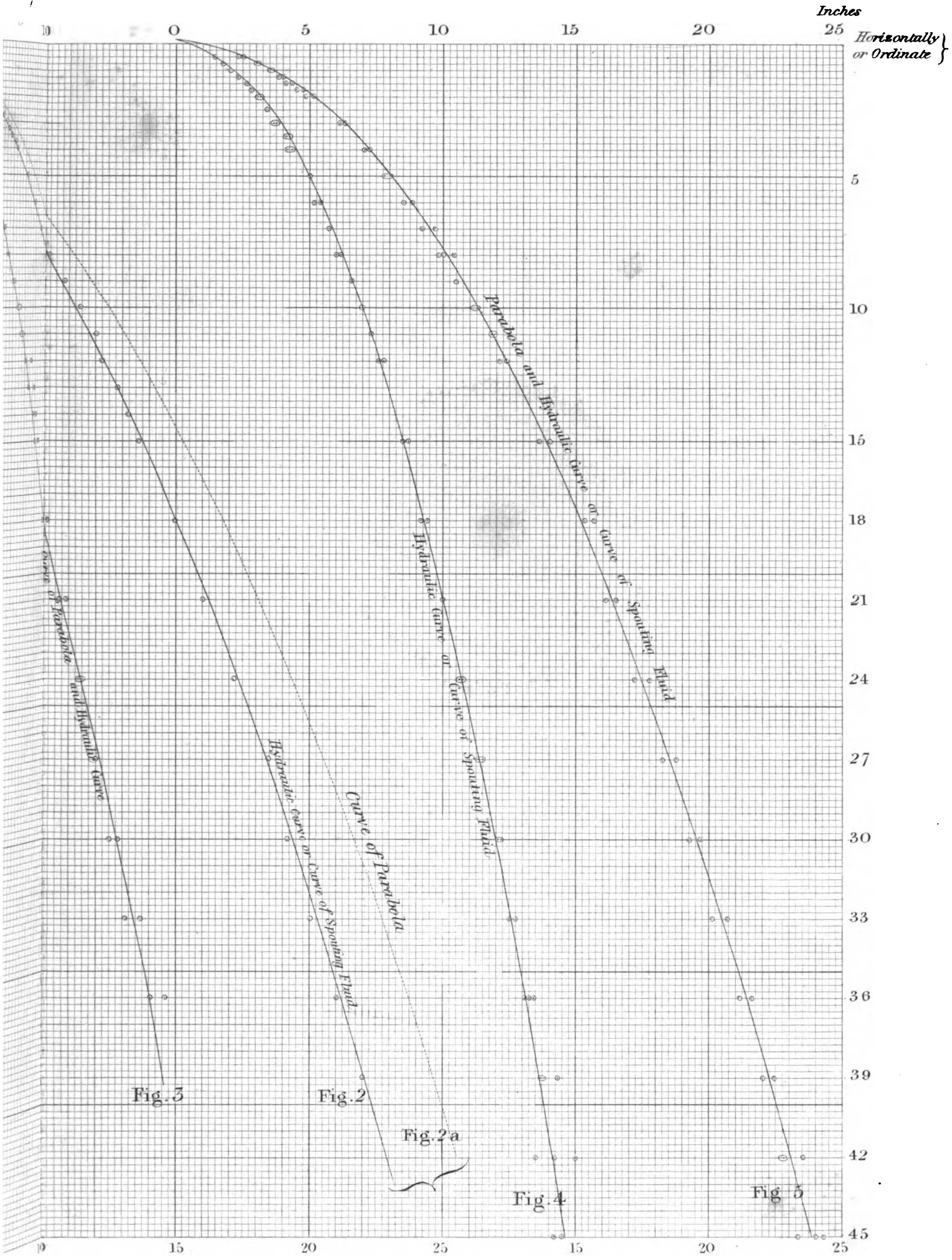


Fig. 1.

[illegible] fc. 16 George Str. Euston Squ.

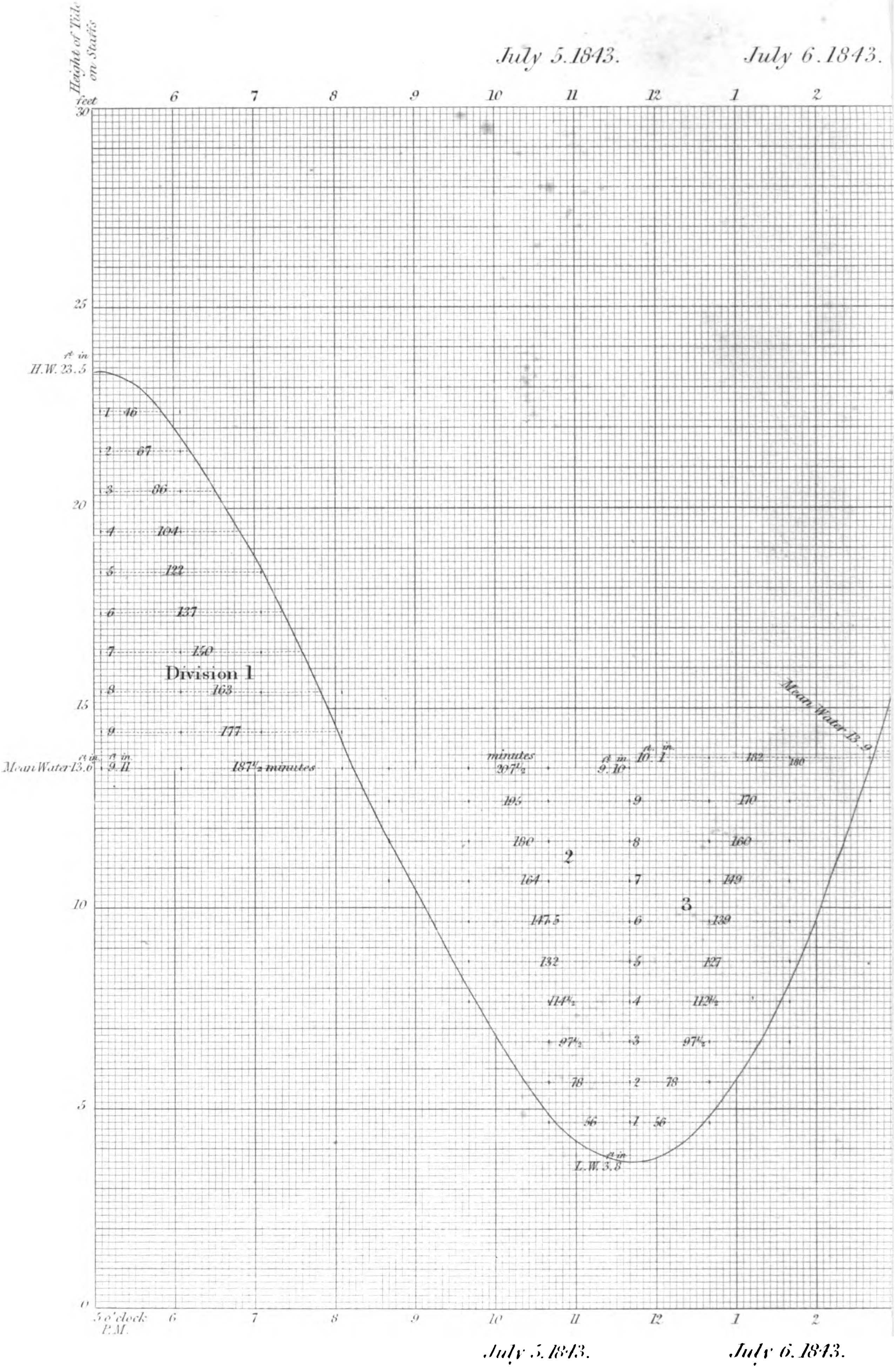
London, Published by John Weale, A

Diagram 1.



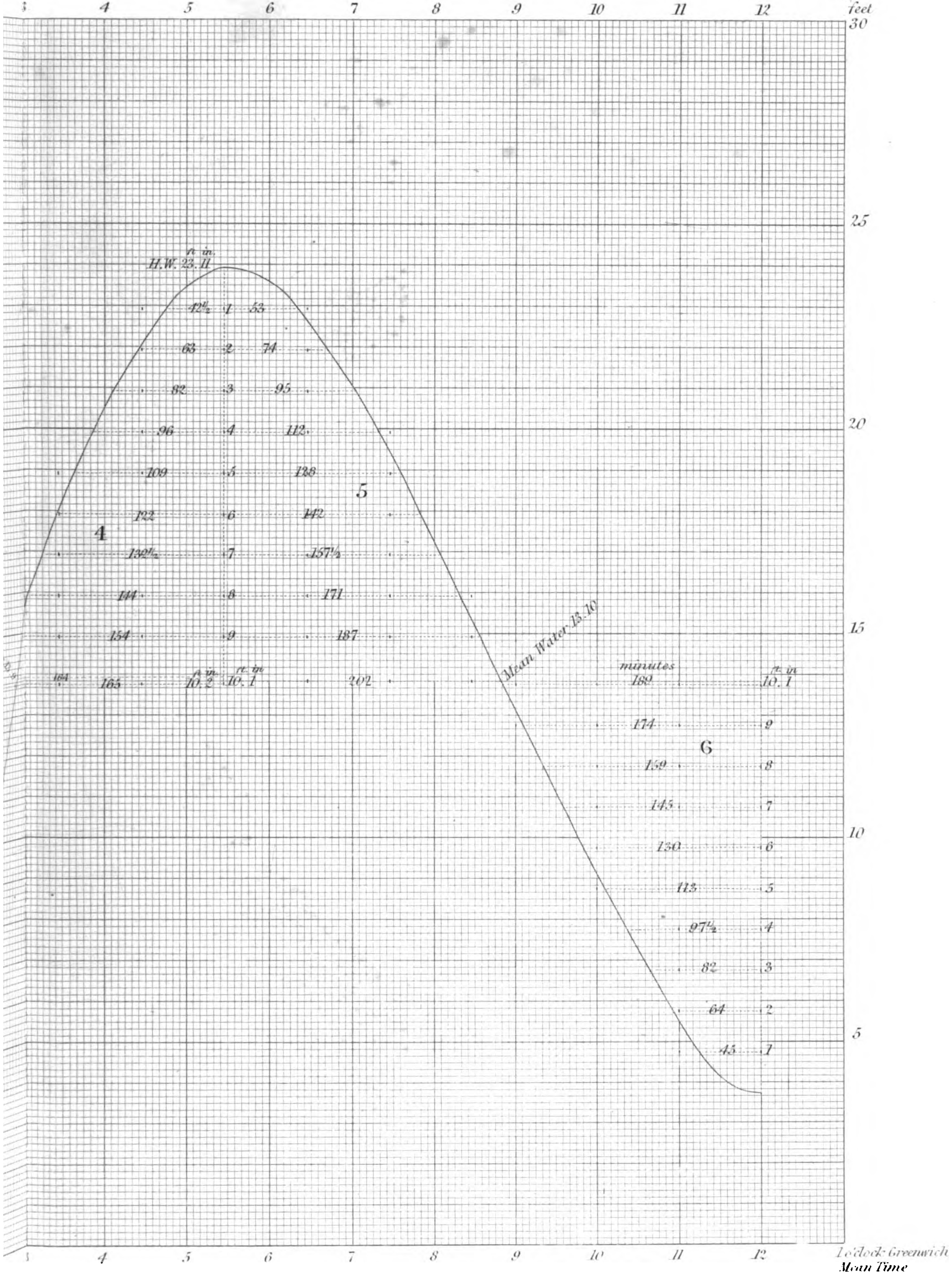
Scale — one fifth of the Natural Size.

rhitectural Library, 59 High Holborn.



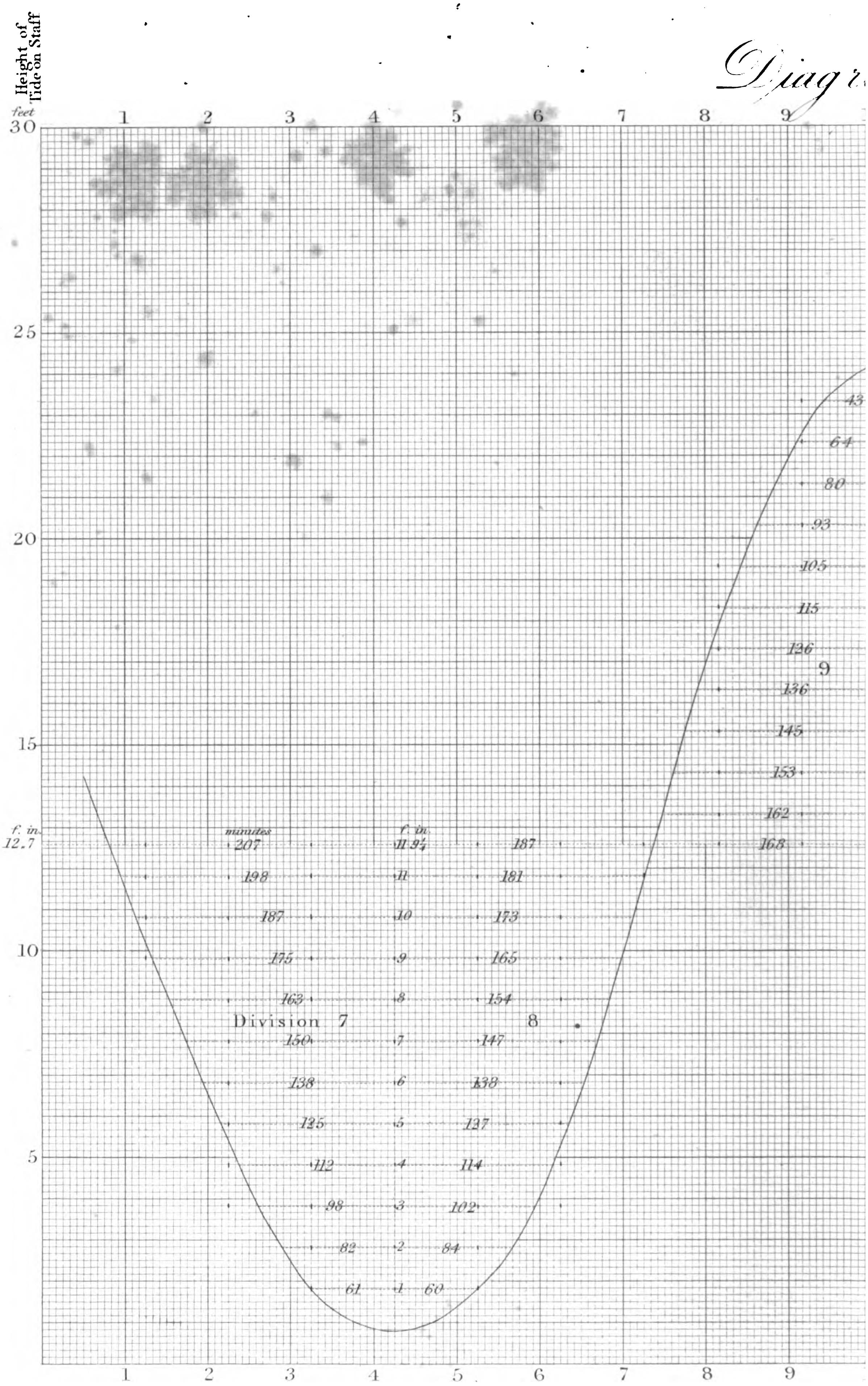
London, John Weale, Architectural

Diagram 2.



Library, 39 High Holborn.

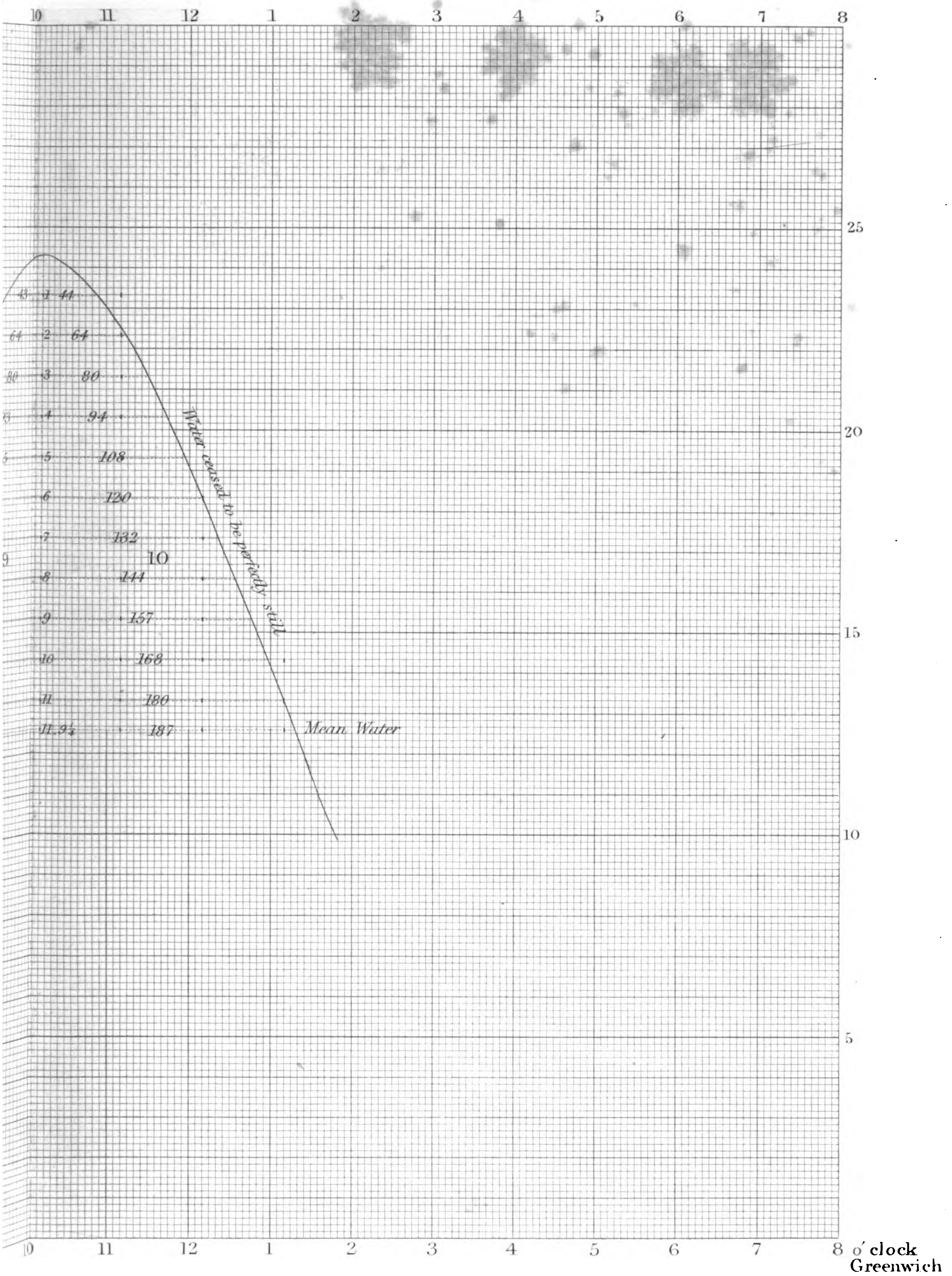
Diagr



P. M. July 10, 1843.

London, John Weale.

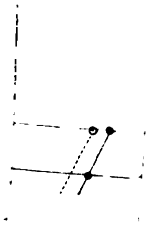
gram 3.



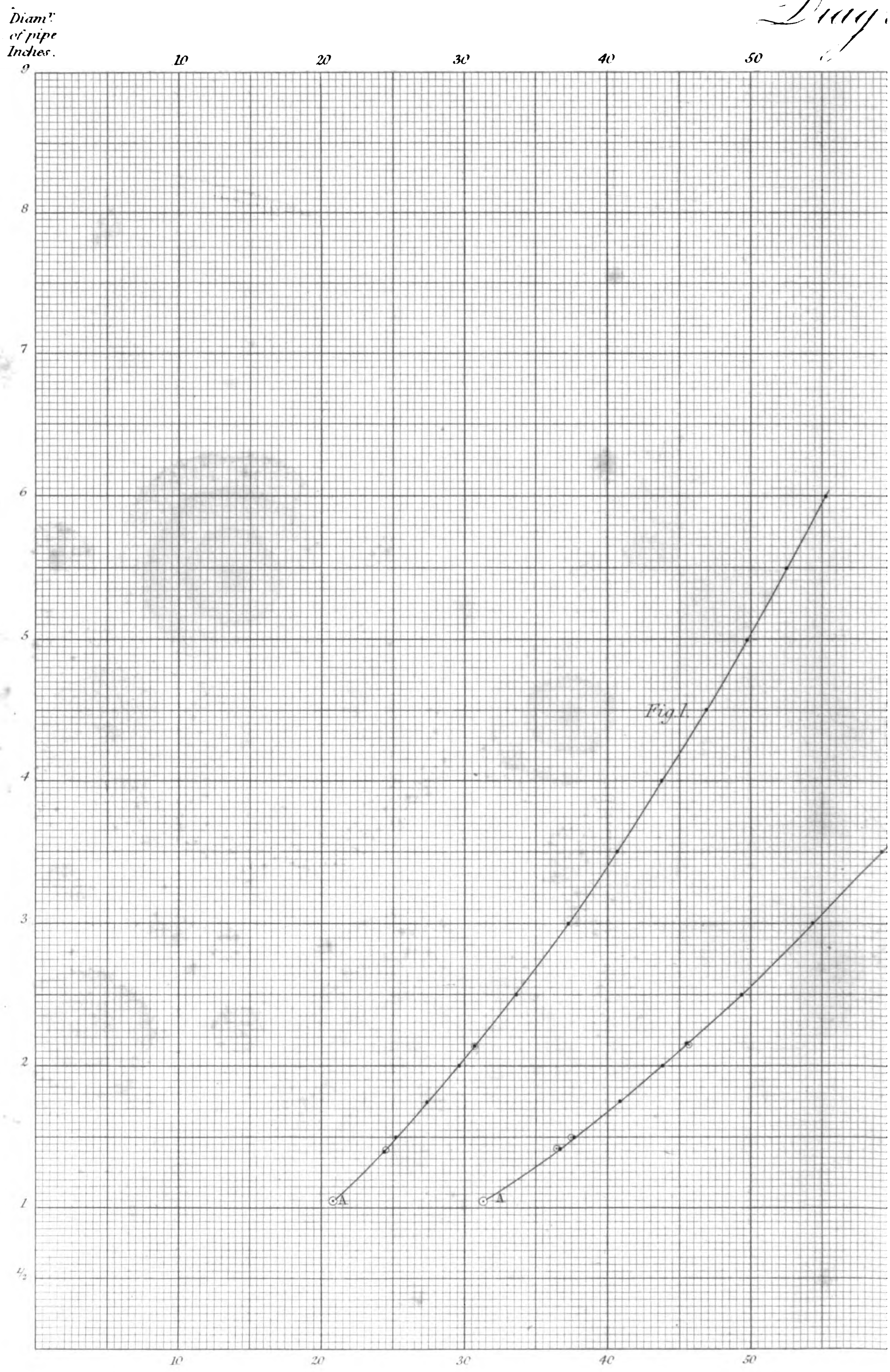
A. M. July 11, 1843.

chitectural Library, 59 High Holborn

B.R. Davies sculp.

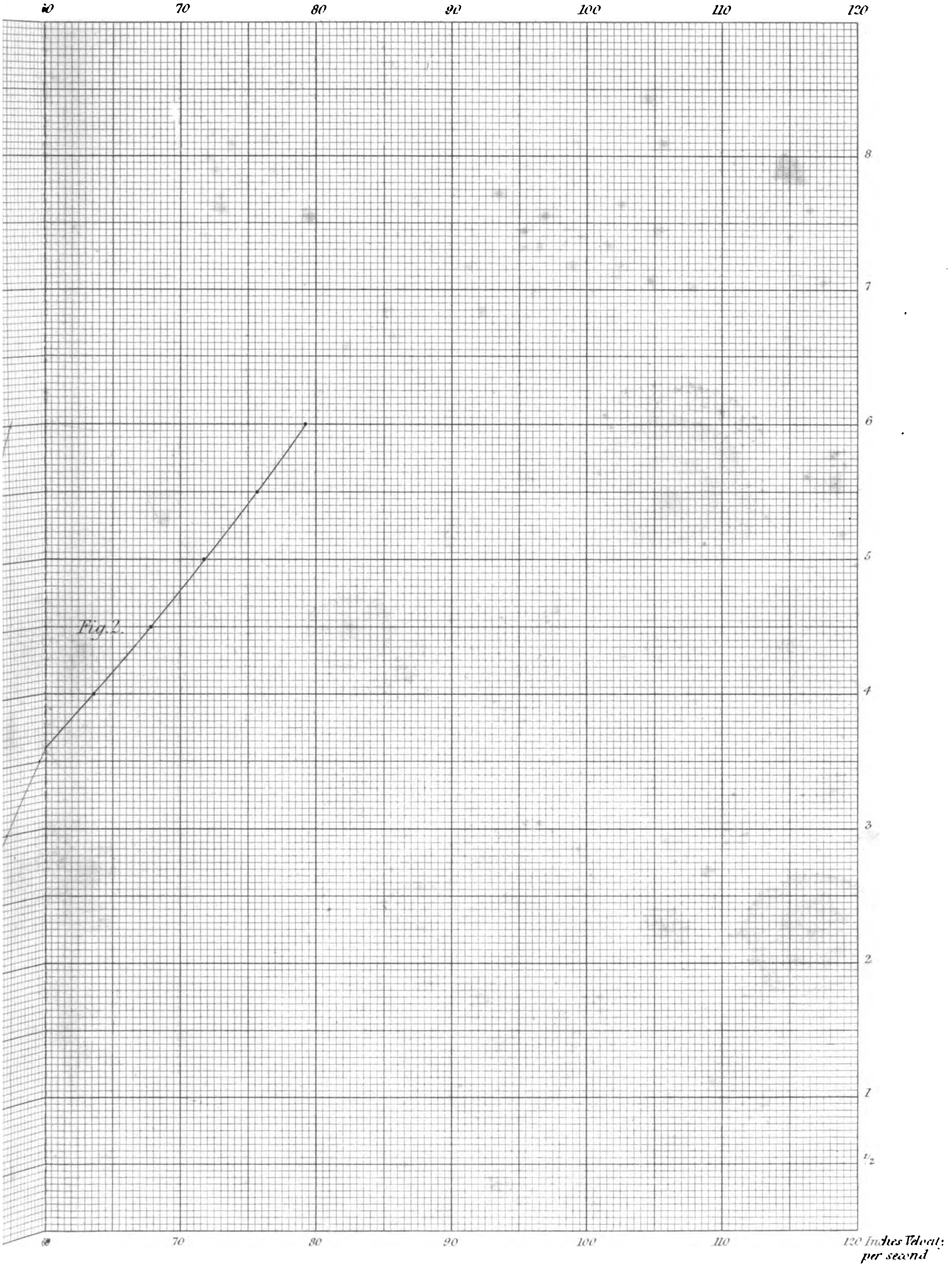


Diag



London, John Weale, Architectura

iagram 6.



Library, 59 High Holborn.

B.R. Davies sculp.

A MEMOIR OF THE THAMES TUNNEL.

BY HENRY LAW.

SECTION II.

CONTAINING A DESCRIPTION OF THE SHIELD, AND OF THE MANNER IN WHICH THE TUNNEL WAS CONSTUCTED.

WHILE the Tunnel is regarded by most ordinary observers with some degree of wonderment and admiration, the, shield is looked upon with little interest, and passed by with only a casual glance. But by the engineer, (and all to whom the difficulties which have been surmounted are known,) it is the shield,—the machine by whose instrumentality the Tunnel has been accomplished, and for the want of which all previous attempts have failed,—which is regarded with the greater interest; and it is the talents and perseverance with which every fresh difficulty was met and overcome, —with which, year after year, against the most adverse circumstances, in the face of the most unfavourable opinions and predictions, and with very little to animate and encourage him, Sir Isambart unceasingly toiled, which they regard with far higher admiration than the Work upon which those talents have been bestowed.

By the engineer it will readily be understood, that the real difficulty was not so much in the actual construction of the Tunnel, as in supporting the ground in the face of the excavation, until the permanent brick structure could be built. From the peculiar nature of the soil under the bed of the Thames, influenced by the very great and constantly varying head of water above it, these difficulties were so greatly increased, that they had been by many pronounced to be insurmountable. It was not, indeed, very difficult to devise a means of supporting the ground, but it was also requisite for the framing or machine by which this was effected to possess the means of being easily moved forward. The difficulty of constructing *one* machine which should combine both these requisites, and which should be capable of supporting the whole pressure of the ground at all times, (even while in the act of advancing,) seemed at first sight to be insuperable—the very propertv of facility of movement appearing to be incompatible with that of great stability. The manner in which both these essentials were obtained in the shield, was by its division into twelve distinct and separate parts, each of which was competent to the fulfilment of either of these duties, the parts being so arranged that they could perform these offices alternately, six of the divisions being employed in supporting the ground, while the other six were making their progress forward.

It has been already said that the shield, as first designed by Sir Isambart, bore a considerable resemblance to the worm, from which the first idea was derived; but the present shield has much more aptly been compared with a man, to whom in its general organization each of these frames or divisions bears a resemblance;—having legs, with both a knee and ankle-joint, with which it alternately steps or walks on in advance of the brick structure; arms, with which it supports and steadies itself, or lends assistance to its neighbours when they require it; and a head, for supporting the superincumbent earth, which can be raised or depressed, or altered in its direction, as circumstances may require.

The external dimensions of the shield were the same as those of the Tunnel, viz., twenty-two feet three inches in height, and thirty-seven feet six inches in width, and it occupied a space about nine feet deep in advance of the brickwork. It was, as just stated, divided into twelve separate frames, each about three feet wide, which were ranged side by side, like so many volumes on the shelf of a library. Each of these frames was again divided in its height into three, by strong iron floors, thus forming thirty-six cells, (technically termed boxes,) which were as perfectly separate and unconnected as if each had been a distinct driftway. The front area of the ground (which was supported and secured by upwards of five hundred small boards, termed polings) amounted to above eight hundred square feet, over a large portion of which the influence of the tide was distinctly felt; and although it is impossible even to approximate by calculation[a] to the pressure which this large area of ground must have occasionally exerted, especially at the time of very high tides, yet some idea may be formed of the enormous stress upon the shield occasioned by it from some of the effects which it occasionally produced, which will be more fully detailed

[a] As an illustration of the difficulty of forming any really accurate estimate of the pressure exerted by the ground upon the Tunnel, upon theoretical considerations, we may mention, that previous to its commencement, the Directors, wishing to be fully satisfied of the sufficient strength of the brick structure to resist the greatest strains to which it was likely to be exposed, consulted two professional gentlemen, both eminent for their skill in calculations of this nature; and while one of these gentlemen stated, that the Tunnel *was not strong enough to be safe*, the other gave it as his opinion, that it was *six times stronger* than was at all requisite.

hereafter. The great advantage of dividing the shield into small cells, is that this large front area of ground, to secure which safely as one surface would be almost impossible, was thus divided into thirty-six portions (termed faces), each of small area, which were easily worked down and secured separately by one or two men; and if from extreme looseness in the ground, in any one of these faces, danger was apprehended, all communication with the contiguous cells could soon be cut off, by introducing boards between the frames; or if any ground made its way in, the run might quickly be stopped by blocking up the refractory box with brickbats and straw.

The pressure of the ground in the front of the excavation was, however, only a portion of that to which the shield was exposed, it having, in addition, to support the weight of the ground which rested upon the top of the frames, and also the lateral pressure of the ground upon the sides of the two extreme frames. The former of these amounted in area to about four hundred square feet, and the pressure upon it was much greater than that upon the front of the excavation, not only from the ground bearing directly upon it, but also from its much greater proximity to the river, by which the influence of the tide was more distinctly felt. The area of the ground composing the two sides of the excavation amounted together to about four hundred and forty square feet, the pressure of which was about the same as that upon the poling boards. The whole of this surface of ground, amounting to about eight hundred and forty square feet, was supported by means of narrow plates of iron (termed staves), the points of which were sharp, and entered the ground, so that they bore some resemblance to sheet piles, and have given occasion to the comparison of the shield to an horizontal coffer-dam.

For the purpose of more readily referring to any part of the shield, the frames were numbered consecutively from I. to XII., commencing with the extreme west frame; and throughout this article, when referring to the frames, we shall make use of the Roman numerals.

Plate 4 is a front elevation of the whole shield, giving a view of that side which was present to the ground, and shewing the form of the brick structure of the Tunnel behind. By an inspection of this plate it will be seen, that the whole of the frames, from II. to XI., are similar in their construction; but the two extreme frames, I. and XII., having to support the whole pressure of the ground upon the sides of the shield, and being connected with the side staves, are slightly different in their details. Plate 5 contains a back elevation of Nos. I. and II., showing the side presented to the Tunnel, and a transverse section of No. III., taken upon the line B, B, Plate 6, which latter is a longitudinal section of the same frame taken on the line A, A, with a portion of the brickwork of the Tunnel in section behind. The sides of each frame were composed of six large cast iron framings (A, A, A), separated by the two floor-plates B, B, to which they were firmly secured by bolts passing through bosses cast upon each, four of which, on each floor, had steel coags, or bushes, half let into both the frames and plates, for the purpose of affording greater steadiness. The form of these framings will be best seen in Plate 6; those in the middle boxes were rectangular, but in the top and bottom they were sloped away behind, to afford more room for the bricklayers while building the brick structure. These framings were strengthened by deep rails or flanges, (shewn in the sectional plans, Plate 11,) which not only gave them great additional strength, but also formed abutments, against which planks could be placed when it became necessary to block up any of the boxes. There were likewise recesses cast in the middle frames for the reception of the two wrought iron diagonal struts, C, C, in addition to which, for the purpose of giving greater lateral stiffness to the frames, two struts (D, D) were afterwards placed at the back of the middle boxes, which could be tightened up by nuts at their upper extremities. The plates (B, B) which formed the floors of the top and middle boxes, to which the side framings were secured, were of cast iron, and were strengthened by deep ribs running across them in both directions, on their underneath side, as shewn in detail in Plate 7. In addition to the bolts, of which there were ten of two inches diameter, four of which were steadied by steel coags, (*a′ a′*, Figure 1,) the castings forming the sides of the frames were still further united by two powerful wrought iron stays (E E, Plates 5 and 6) secured to projecting studs at the top and bottom of the back part of the frames, and connected by gibs and keys with two of the bolts passing through the floor-plates. The lower part of the side framings of the bottom boxes were securely connected by two powerful wrought iron braces, (F and G,) to which they were firmly bolted, and the sides of the top boxes were similarly secured by the braces H and I, which also carried the ceiling of the shield. Although a single frame, when viewed from the front, (as in Plate 4,) has the appearance of being very lank and weak, by an inspection of Plate 6 it will be seen that in the direction in which they were strained they possessed great strength; resembling in form two large open iron beams of considerable depth, firmly united and braced together. By considering the frame in this way, as an open beam, supported at each extremity by the abutment screws, and uniformly loaded upon its front side by the pressure of the ground, the strain which each frame would require to produce fracture would be equal to above a thousand tons; and although this would appear (as in fact it was pronounced to be by several engineers at the time of its construction) far stronger than necessary, experience has proved that it was not even *strong enough* to resist the shocks to which the shield was occasionally subjected, by the impetuous bursts of loose ground, urged against it by a head of water sometimes equal in height to the new Custom-House, as every one of the frames, without exception, was fractured in some of its parts.

Each frame was supported upon two jacks, K, K, (termed the legs,) which having to carry not only the weight of the frame, but also the whole pressure of the superincumbent ground, were necessarily required to be of great strength. They are shewn in detail in Plate 8, in which Figure 1 is a sectional elevation of one of the legs, each of which consisted of three parts—the spindle or screw, the socket, and the shoe. The shoe, L, was a broad plate of wrought iron, five feet long by sixteen inches wide, perfectly flat on its underneath side, which received the whole of the pressure from the legs, and served to spread it over a larger surface. The shoes did not bear directly upon the ground, but the whole of the bottom part of the excavation was covered with three inch elm planks, (*b′*, *b′*, Figures 1 and 2,) which were forcibly screwed down by a jack, *c′*, from the side framing, and *held* down until the shoe was advanced sufficiently to bear upon them, the front of the shoe being formed in two prongs, or toes, as will be seen in the plan, Figure 2, which could be brought to bear upon the plank without disturbing the jack, *c′*, between them. To the back part of the shoe a holdfast, *d′*, was attached, which prevented the planks from being forced up by the swelling of the ground when relieved from the weight of the shoes, and held them down until the brickwork was put in. By thus forcibly compressing the ground upon which the Tunnel was to be built, and making the whole weight of the shield (amounting to about two hundred tons) pass over it, all subsequent settlement in the brick structure was prevented, and a firm and secure foundation for the Tunnel insured. The lower part of the leg or socket, K, was connected to the shoe by means of a universal joint, consisting of a ring or collar of iron, (*e′*, Figure 4,) connected with the leg and shoe by two pins, *f′* and *g′*, at right angles to each other, which allowed of the shoe adjusting itself to any unevenness or inequality in the surface of the ground, without affecting the perpendicular position of the legs, or throwing any irregular strain upon the frame, and from its use, has been compared with the ankle-joint of the human leg. It will be seen by Figure 1, that the end of the leg terminated in a spherical head, which bore in a hollow cup in the shoe; and that the metal ring, *e′*, had no strain upon it, but served only to connect the two parts together. By an inspection of Figure 2, which is a sectional plan of one of the bottom boxes, it will be seen that the lower part of the leg was flattened on the sides, and passed through a groove at the lower part of the box, formed by the bar *h′*, (attached to the wrought iron bracing F G,) and the side of the framing, which served as a guide to steady the leg, and also prevented the socket from turning round. The upper part of this socket (K) contained a gun-metal box, *k′*, with a female screw for the reception of the strong wrought iron screw and spindle, M, which was composed of two pieces, the lower part or screw having a double head, and being connected to the spindle by means of the joint *l′*, (Figure 6,) which answered a similar purpose to the knee-joint in the human leg, allowing it to move either backward or forward; the spindle passed up through the lower floor-plate, B, into the middle boxes, being steadied by passing through the hollow column or standard, *m′*, and terminated in a capstan-head, N, by means of which a very considerable power could be applied to turn the screw, M, for tightening up the legs, either for the purpose of raising the frame or for compressing the ground; a steel washer, *n′*, was inserted between the bearing surfaces of the spindle and floor-plate, for the purpose of lessening the friction and facilitating the turning of the screw.

We now pass on to describe a very important part of the shield, as an auxiliar to the legs, viz., the arms or slings, O, by means of which the weight of any frame could be wholly thrown upon its two neighbours, and its own legs entirely relieved from pressure. They are shewn in detail in Figures 4 and 5, Plate 7, and consisted of two very strong wrought iron bars, O, O′, united together by strong checks, P, P, through which two sets of gibs and keys (*p′*, *q′*,) passed, by means of which the slings could be lengthened or shortened at pleasure; the ends of the sling terminated in large holes, which fitted on to projecting pins (*r′ r′*) on the sides of the floor-plate B B. The upper ends of the slings being attached to the top floor-plates of the odd numbered frames I., III., &c., and the lower ends to the bottom floor-plates of the even frames, II., IV., &c., (as shown in Figures 2 and 3, and in the section of the sling, Figure 4,) by driving in the upper key (*p′*), and thus *shortening* the slings, the *even* frames would be raised, and supported by the odd; but by driving in the lower key (*q′*), and *lengthening* the slings, the case would be reversed, and the *odd* frames would be supported by the even. The great value of the slings will readily be understood, since by their aid the weight of the shield could be more equally distributed over the bottom of the excavation; or if any frame had a tendency to sink, from the ground upon which it stood being soft or loose, its weight could by means of them be thrown upon its two neighbours; or again, whenever it was necessary to remove any of the legs for the purpose of being repaired, the slings took their place, and were made to support the frame.

The ground composing the roof or ceiling of each frame was supported by two iron slippers or staves, Q, Q, eighteen inches wide and ten feet six inches long, the upper surfaces of which were planed perfectly smooth, so as to offer as little resistance as possible to their being advanced from friction against the ground. The details of these staves are given in Plate 9, in which Figure 1 is an underneath view of one of them, and Figure 2 a longitudinal section of the same, from which it will be seen that it consisted of three pieces, termed the tail, the body, and the point, which were united together by strong flanges; the transverse section will be seen by Figure 3 to be in the form of a hollow trough, having deep ribs running along each side for additional strength. The front or point of the stave was divided into two pieces, (as shown in Figures 1 and 6,) to afford greater facility in removing them in case of a fracture, and were tapered off gradually to a sharp edge, to enable them the more easily to cut through the ground, into which they always entered about six inches in advance of the front of the excavation, for the purpose of affording greater protection to the upper faces. The tail of the stave terminated in a thin plate of wrought iron *s'*, passing over the top of the brickwork, which it always overlapped several inches, (as shown in Plate 6,) thus leaving no part of the roof of the excavation without support,—a most necessary precaution, for the ground was frequently of so loose a nature, that it was not safe to leave even the smallest portion uncovered; indeed, it was sometimes extraordinary to observe through what minute crevices the ground would make its way; pieces of clay being forced through apertures apparently much smaller in size, the lump swelling up after it had come through, as though just relieved from great pressure. The top staves were supported from the frames in such a manner that they could be either raised or lowered bodily, or could have their inclination varied according as the excavation was declining, horizontal, or inclining upwards. The middle portion, or body of the stave, rested upon a cast iron saddle, R, (Figures 7 and 8,) the rubbing surfaces of both the stave and saddle being planed perfectly smooth, and slips of wood, *t' t'*, interposed between them, (as shown in the transverse section, Figure 3,) for the purpose of lessening the friction. On the underneath side of the saddle were two semicircular recesses, *u' u'*, (Figures 7 and 8,) which fitted on to two circular pins, T T, (Figure 3,) projecting from the sides of the wrought iron swivel-piece, S, and on which the saddle could turn as a centre, when it was required to vary the inclination of the stave. The swivel-piece, S, was supported from the wrought iron bracings, H and I, of the top box, resting in front upon two raised lumps or heads, U U, which fitted into the semicircular recesses, *v' v'*, on the underneath side of it, (Figure 1,) and at the back supported by a screw, V, (technically termed the ball screw,) passing through the box *w'* in the back bracing, H, and by means of which the swivels, together with the saddle and staves, could be raised or lowered bodily. To the back flange of the top staves a powerful jack, W, (termed the tail-jack, Plates 5 and 6,) was attached, which was fitted at its lower extremity to a pin (x') passing through a boss on the lower part of the side framings; this jack consisted of two sockets, the upper one containing a right-handed, and the lower one a left-handed female screw, into which a double screw with a capstan-head fitted. By raising or lowering only the tail-jack, the stave would turn upon the pin T as a centre, and could have its inclination regulated to any angle that was required. But if it was desired to raise or lower the stave bodily, without altering its inclination, this could be effected by raising or lowering the ball-screw, V, simultaneously with the tail-jack.

The description which has just been given applies to the whole of the frames from II. to XI., each of which had two top staves; but it will be seen by an inspection of Plate 9, Figure 3, which is a transverse section of the upper part of No. I., that that frame had three top staves, (Q, X, and Y,) which was also the case at No. XII. The inner one, Q, was precisely similar to the staves of the other frames, but the other two were slightly different. The outside or corner stave, X, as will be seen by the section, Figure 3, was of a different form to the other stave, resembling the letter ɪ turned upside down; it was fifteen inches deep, and fourteen wide, and having to support the ground, both at the top and side of the corner of the excavation, had both its external surfaces planed perfectly smoooth; the middle stave, Y, was similar to the other stave, Q, with the exception of being only eleven inches wide. The angle-stave (X) and the narrow stave (Y) each rested on a separate saddle, both of which, however, were supported upon the same swivel-piece, which only differed from that of the other staves in being much wider, the saddle turning on the circular pin, T, and the swivel being adjusted and supported in a manner precisely similar to those already described.

The ground at the side of the excavation was supported by slippers or staves, (Z, Z, Figures 2, 3, 4, and 5, Plate 9,) very similar in form and section to those used for securing the ceiling, which have been already described; they were about ten feet long, and twelve inches in width, and had their external surfaces planed perfectly smooth to lessen the friction against the ground as much as possible, and the points were made sharp, to enable them to enter it more readily; to the tails were also attached thin wrought iron plates, (as in the top staves,) which passed behind the brickwork, and left no portion of the side ground unsecured. By Figure 3 it will also be seen that the angle stave, X, had a thin plate of wrought iron, y', attached to its lower edge, which passed down behind the upper side stave for the same purpose. The side staves were supported by resting against the external framing (A) of the extreme frames, which were not sloped away in a similar manner to those of the other frames, but were of an equal width both in the top, middle, and lower boxes, and had an additional rail running down the middle of each framing, to which the side staves were connected. The front and back rails also had a narrow projecting surface, z', z', planed perfectly smooth, upon which the side staves were supported, and against which they slid, the bearing edges of the staves, a, a, being increased in width to an inch and a half, and also planed perfectly true. To connect the side staves securely with the frames, and prevent their being separated from them, each stave was provided with a long bolt, b b, fixed at each end by passing through a boss cast upon the body of the stave; these bolts also passed through a hole in a block of cast iron (termed the travelling block), c c, which was screwed to the middle rail of the frame in such a manner as to admit of its turning upon the screw β, as a centre, by which means the inclination of the side staves could be varied at pleasure. By this method of attachment, although the staves were securely held by the frames, they could either of them be advanced separately, the bolts, b, passing through the holes in the travelling blocks, c, which they fitted very loosely, the staves resting not upon the bolts, but bearing upon the projecting surface γ on the upper part of the travelling block c, (as shown in the section, Figure 3,) by which means they were made to move forward in a true parallel direction.

We have already mentioned generally, that the ground in the front part of the excavation was supported by about five hundred small boards, termed polings. It now remains to describe more particularly the way in which this was effected. These boards, the details of which are given in Plate 10, were each of them three feet long, (the width of a frame,) three inches thick, and six inches wide, and were placed horizontally against the ground, (as shown at d d, Plates 5 and 6,) every box having its own polings. To the end of these boards small iron plates (δ δ, Figures 3 and 4) were firmly screwed, having small hemispherical cups for the reception of the heads of the small jacks or poling screws, e e, (Figures 1 and 2, and Plate 6,) by which they were screwed against the ground and supported, and the other end of which bore against the front rail of the side frames, in which there were a great number of semicircular recesses, ϵ ϵ, (Plate 4, and Figure 6, Plate 9,) for their reception. By an inspection of Figure 1, Plate 10, it will be seen that the ends of the poling screws which bore against the frames were of a peculiar form, having not only a semicircular head, η, but also a projection or notch, θ, about three inches from the end, both of which could be placed against the frames, in the recesses, ϵ, and the use of which was to save the trouble of running out the screws when the polings had been worked forward, as will be seen in Figure 2, where the screws of the lower polings have the notches, θ, resting against the frame, but the two upper polings having been advanced three inches, instead of running out the screws to that extent, which would involve much time and trouble, the poling screws were simply shifted from the notch, θ, and placed with their ends, η, in the same recesses. The poling screws, *e*, however, only served to hold the polings against the ground, and prevent their being forced in by its pressure. But it not unfrequently happened that owing to extreme softness or looseness in the ground, cavities would be formed in front of the polings, which, relieved from the front pressure, have moved forward sufficiently to allow of the poling screws dropping from their places, and have then fallen in themselves, leaving the ground without any support, and exposing the safety of the works in a most dangerous manner. From the same cause, and also from sudden settlements or movements in the ground, the polings have occasionally canted or turned edgewise. In order to obviate this inconvenience, Sir Isambart devised a system of connecting the poling-boards together so completely, that each face formed, as it were, a single panel; the manner in which this was effected is shown in Figure 3, Plate 10; near each end of the poling were two screws, κ and λ, having flat heads with holes through them, and screwing into nuts let into the front of the boards, the lower screw, λ, passed through a hole in a flat hook, μ, which was just of such a length as to engage the upper screw, κ, of the next poling below it, and by tightening up the screws κ and λ, the two polings were firmly held together; in a similar manner the whole of the polings in a face could be securely connected together, and when it was desired to remove any one of them, it was easily effected by slackening the screws κ and λ, which engaged the links holding that poling, which might then be turned aside, and the board removed, (as shown in Figure 3,) without disturbing the other polings either above or below it. As a still farther security, to prevent the poling boards from falling outwards, there were in each face about half-a-dozen pulling jacks, or tie screws, ($\pi\,\pi$, Figure 1,) having one end hooked on to the eyes of the screws κ and λ, and the other secured to eye-bolts in the front rails of the frames.

We have now to explain the manner in which the frames were supported in a perpendicular position, and prevented from receding or being forced backwards by the pressure of the ground against them; and when it is considered that nothing could be more dangerous, or more likely to be attended with calamitous consequences than such an occurrence, the great importance of firm and unyielding abutments for the shield is evident. This was effected by having two very powerful screws (termed from their use the abutment screws) in each frame, one in the upper and one in the lower box, attached to the wrought-iron braces, F and H, and bearing against the brick structure of the Tunnel, as shown in Plate 6. The top abutment screw is shown in section in Plate 10, Figure 5, from which it will be seen that they consisted of two parts, the socket *f* and the screw *g*; the former, which was of cast-iron, bore against the back wrought-iron bracing, H, to which it was connected by a pin passing through two staples, forming a joint upon which the screw could be turned out of the way of the bricklayers when it was required to put in the brickwork behind it. The other end of the socket contained a gun-metal box, *k*, with a female screw, into which the other part of the abutment screw, *g*, fitted; on this screw was a capstan by which it could be turned round, and it terminated in a circular steeled head, fitting into a hollow cup in the wrought-iron abutment plate, *h*, which latter bore against the end of the brick body of the Tunnel, thick blockings of wood being interposed between the brickwork and the plate, (as shown in Plate 6,) for the purpose of throwing the pressure over a larger surface, and preventing the former from being crushed; for the pressure upon these screws was sometimes so considerable, as not only to crush both the wood and brickwork, but even to split the abutment plate *h*, and to bend the screws.

These screws not only served the purpose of an abutment for the frames, to prevent them from receding, but it was by means of them that the shield was forcibly screwed forward or advanced. We have already stated that the frames were advanced separately, and that six of them were employed in supporting the ground while the other six were being moved forward, and the manner in which this was accomplished, was by removing the poling screws from off the frames which were to be advanced, and placing them upon the front rail of the two contiguous frames, there being a sufficient number of the holes, *e*, in the front of each frame to receive its neighbour's as well as its own poling screws. By this means the frames were relieved from all front pressure, and had no other obstacle to their progress than the resistance occasioned by side friction. To reduce this as much as possible, and also to make the frames move in a correct parallel direction, there was a contrivance, which we will now describe, and which is shown in detail in Plate 7. Figure 1 is an underneath view of the lower floor-plate of No. III., with a portion of those belonging to Nos. II. and IV., on either side of it; *l l l l*, are four wrought-iron sectors of circles, or as they were termed, quadrants, the circular portion of which worked against the inside edge of the recesses *m m*, and the head or centres bore against the floor-plates of the neighbouring frames. The recesses *m m*, for the reception of the quadrants, which were of wrought iron, were fixed to the floor-plates by bolts, but the holes through which they passed were elliptical, admitting of a slight motion in the recesses, for their adjustment, which was effected by two long wedges, *n n*, introduced between the pieces, *m*, and the middle flange of the floor-plates, by tightening which the recesses could be separated farther apart, or vice versâ, and thus any required distance preserved between the frames. A large wrought-iron plate, A′, was screwed over the quadrants, to keep them in their places, and prevent any gravel or sand getting in between the bearing surfaces and interfering with their correct action; in Figure 1, this plate is removed from the back pair of quadrants, to afford a better view of their method of action. There were four of these quadrants to both the top and bottom floor-plates of all the odd-numbered frames, viz., two in front and two behind. The heads of the quadrants, as already stated, bore against the floor-plates of the even-numbered frames, to receive which there were steel cups, *o o*, fitting in semi-cylindrical recesses, *p p*, on the side of the floor-plates, which allowed of the frames deviating in their relative levels, without interfering with their correct action, the cup, *o*, sliding up or down in the recess, *p*, which being uniformly cylindrical, in nowise affected the working of the quadrants. If we consider the enormous pressure to which the sides of the shield were subjected, and the consequent amount of friction which would have resulted had the frames been in actual contact, the great importance and utility of the quadrants will be clearly perceived.

The efficient and correct action of the quadrants, and in fact of the whole shield, depending on the systematic and regular advance of the frames, a contrivance termed the regulator was attached to each side of the odd-numbered frames, both in the top and bottom boxes, by which not only the advance of its own, but also of the intermediate frames, was regulated and governed. In Plate 8, Figures 1, 2 and 3, these are shown in detail. They consisted of a strong iron boss, *q q*, screwed on to the side-framing of the odd-numbered frames, which projected into the contiguous frames on either side, and contained two screws, *r* and *s*, with flat heads, so arranged that the head of the screw *r* came into contact with the front rail of the even-numbered frame, when the odd frame had been advanced far enough before it; and in like manner the back rail of the even frame was stopped by the head of the screw *s*, when that frame had been sufficiently advanced before the odd.

The quadrants only served to keep the frames from approaching too near to each other, but it was also necessary to prevent them from separating or spreading, and this was effected by having a strong double tie-bolt, (*t*, Plates 5 and 6,) extending from one side of the shield to the other, being firmly secured to the underneath side of the top floor-plates of the two extreme frames. Although this at first sight might seem to have been quite unnecessary, the pressure of the ground upon the sides of the shield appearing to be amply sufficient to prevent any separation of the frames, still experience proved it to be a most requisite and useful auxiliar.

From the foregoing descriptions it will be seen, that although the shield, for facility of movement, was divided into twelve separate and similar machines, each capable of independent motion, they were so securely coupled together that the whole composed a firm and efficient barrier to the ground, and afforded as ample a protection to the workmen as could have been obtained by one solid framing.

We will now proceed to describe the manner in which the several operations of excavating the ground, advancing the shield, and constructing the brickwork in the space thus obtained were successively performed. By a reference to Plate 11, Figure 1, which is a sectional plan of the middle floor of No. III., together with a portion of Nos. II. and IV. on either side, it will be seen that the front rails of the frames do not stand in a line, but that the two latter are represented as being three inches in advance of the former, and the poling boards being in both cases seventeen inches from the front of the frames, are also three inches forwarder in Nos. II. and IV. than in No. III.; it will also be observed that the poling screws which support them are placed upon their own frames. Now the first proceeding is to remove the poling boards of No. III., (the backward frame,) one or two at a time, depending upon the firmness of the face, and to cut away about three inches of the ground, which having been done, the poling and the poling-screws are restored, but instead of being placed upon their own frame, the left hand screws are placed upon No. II., and those on the right hand upon No. IV.; the relative position of the frames and their polings at this stage is shown in Figure 2. When the whole of the poling boards of No. III. have been thus *worked down,* (as it was technically termed,) and the poling screws removed on to the other two frames, No. III. is screwed forward or advanced six inches, (in the manner which will be presently described,) and is brought into the position shown in Figure 3. As soon as this has been effected, the poling boards of No. III. are again removed, the ground worked down another three inches, and the poling screws transferred from Nos. II. and IV., and once more placed upon their own frame, as shown in Figure 4, in which it will be seen that the poling boards are again brought to an equal distance (viz., seventeen inches) from the front rails in all three frames, and that each frame supports its own poling screws, the only difference between their relative positions now, and as shown in Figure 1, being that Nos. II. and IV. are now as far (viz., three inches) behind No. III., as they were in advance of it before. The procedure which we have just described in No. III., is simultaneously being carried on in all the other odd-numbered frames, and as soon as this has been accomplished, and the whole of those frames brought forward, it is transferred to the even-numbered frames, (now in their turn behind,) which are in a similar manner worked down and forwarded. It will thus be seen that the whole shield was never in a line, but that either the odd or even-numbered frames always stood about three inches in advance of the others. In the foregoing description we have stated that the poling boards were removed and the ground worked down twice for each advance of a frame, that being the method of procedure adopted, when from the looseness or quickness of the ground, it was not deemed prudent to keep the face open a sufficient length of time to work out the ground to a greater depth than three inches. When, however, the ground was firm enough to allow of its being cut to a depth of six inches at a time, it was always done, and the face being then only worked down once for each advance of the frame, the manner of proceeding was slightly different; the poling boards were kept at a distance of twenty-one inches from the front rail of the frames, which were, as before, three inches in advance of each other; as all the frames carried their own poling screws, the first proceeding was to remove these from the hindmost frames, without disturbing the poling boards, and transfer them, as already described, into the foremost frames on each side; the former being thus relieved from the pressure of their poling boards were all advanced six inches, which brought them three inches in advance of the other frames, and with their front rails only fifteen inches from their own poling boards, which were then removed and worked forward six inches, again bringing them to their former distance of twenty-one inches, and the poling screws were replaced upon their own frames.

We next proceed in order to describe the manner in which the frames were advanced. We have already explained that the whole of the poling screws were first removed from the front of the frame; the next proceeding was to advance the top staves, which were forwarded one at a time by means of a small abutment screw bearing against the brickwork, and applied to the back flange of the stave; if the ground at the top of the excavation consisted of gravel, or was found to be very hard, it was removed from the point of the staves, when the face was worked down, and good puddled clay substituted in its place, that the sharp edge of the stave might not be broken, and at the same time to enable it to go forward more easily. Although we have here described the top staves as being advanced separately and before the frames, this was not always done; but if the frame was found to go forward without much difficulty, it was then usual to connect it with the staves, by inserting a blocking between the saddle, R, and the front flange, and to advance them both together, by doing which a considerable saving of time was effected. The next step was to tighten the keys of the slings, so that the frame about to be advanced might be supported by them. This having been done, the screws, M, of the legs were slackened sufficiently to allow of the shoes being pushed forward six inches, the legs being brought into a raking position, as shown in Plate 6. The screws, M, were then gently tightened, it being very important that the frame should not be suffered to go down or sink while being advanced. The top poling board was then removed from under both the floor-plates, in front of the edges of which puddled clay was inserted, as already described with regard to the top staves. If the ground was sufficiently firm, it was usual to keep these polings out while the frame was being advanced. Things being thus prepared, a sufficient force was applied to both the upper and lower abutment screws, and the frame was steadily and equably screwed forward, the distance to which it was advanced being governed by the regulators *q q*. Great care was taken that the frames moved parallel, by turning both screws simultaneously, and a man was stationed in the middle boxes with a plumb-line, whose duty it was to see that the frame preserved its proper degree of inclination, the frames always being kept perpendicular to the line of direction of the Tunnel, whether horizontal or inclined. As soon as the frame had been advanced, the poling boards under the floor-plates were replaced, and the legs and ball-screws, v, as also the tail-jacks, w, were tightened up with a very considerable force, it being a most important condition that the ground should always be pressed against or compressed as much as possible by the shield; experience having shown that it was not sufficient for the shield simply to support the ground, but that it was also requisite to keep a constant and steady pressure against it. In the extreme frames the operation of advancing was similar to that in the other frames, but the side staves were always advanced separately by means of a small jack applied to the back flange, and bearing against the brickwork. The resistance occasioned by the friction of the side staves causing the extreme frames to require a greater force than the others, a third abutment screw was occasionally applied underneath the top floor-plate for the purpose of facilitating their advance and relieving in a measure the other screws. As the frames were never, or at least very seldom, advanced more than six inches at a time, it was necessary to advance eighteen frames, or the whole shield once, and then half the frames again, for the addition of every nine inches in length to the Tunnel.

The centering used for the construction of the Tunnel is shown in section in Plate 6; it consisted of a semicircular ring of iron, *u*, strengthened by an inner flange, and covered externally with wooden segments, *v*, which latter coincided in form with the intrados of the arch, and were about sixteen inches wide. The centering was supported by a long bar, *x*, which rested at one end upon the top floor-plates of either Nos. IV. or IX., and was supported at the other by a jack, *w*, by means of which the centre could easily be either raised or lowered; there was also a screw, *y*, upon the centre itself for a similar purpose. The centre, although very slight in its construction, was amply strong enough for the purpose for which it was designed, for the inner ring of brickwork, being laid in perfectly pure cement, set almost as soon as built, and the centre had little or no weight to carry, its real use being more for a template or profile to guide the bricklayers in giving a correct form to the arch. As soon as the shield had been sufficiently advanced to leave space for a nine-inch ring of brickwork, the centre was set and the ring turned without delay, the brickwork always being kept as close behind the shield as possible; which not only added to the security of the works, but also lessened the strain upon the tail-plates of the top staves by leaving less of them unsupported. The invert and piers were usually built in eighteen-inch work, with English bond, the cement being gauged with sand in equal proportions. The foundation and lower part of the piers were frequently built of blocks about eighteen inches square, which was much more expeditious than building them in the ordinary manner, and as the lower part had occasionally to be put in under water, the work could be made much sounder by this method, and with a much smaller consumption of cement. The arches and spandrils were usually built in nine-inch rings, although some portions of the Tunnel (which will be detailed in a future section) have been built in four and a half, and even in three-inch rings. In the construction of the latter part of the Tunnel two courses of Yorkshire landing were inserted at the springing of the arches, as shown at B′, B′, Plate 6, which not only served for a bond to the brickwork, but also occasionally caused a saving of time by enabling the centres to be set and the arches turned without waiting for the side piers being built, which were sometimes delayed by the extreme frames. Although the building of the brickwork and the excavation of the ground could be carried on simultaneously, the bricklayer being at work at the back part of the shield at the same time that the miner was engaged in the front, still it occasionally and unavoidably happened that the progress of either the brickwork or the shield was delayed by the other, in the one case the shield having to wait until the brickwork was brought up to it behind, and in the other the bricklayer having to wait for the advance of some of the frames to obtain sufficient space to turn the ring. As the abutment screws and plates had to be removed for the insertion of the brickwork behind them, and as the abutment screws of any frame were never allowed to be removed under any circumstances while the poling screws were in bearing on that frame, it also sometimes occurred that the brickwork was delayed upon this account. Great attention was paid to securing (or, as it was technically termed, *pinning up*) the wrought-iron tails of the top staves, so as to prevent any loose ground from making its way in there; and this was effected by thin folding wedges, driven tightly in between the brickwork and the tail-plate. For the convenience of the miners and bricklayers, and to afford a readier access to the top boxes of the shield, a timber stage or platform was constructed in each arch, and carried on as the work progressed, being formed by joists laid upon the projecting springing course of the arches, and floored with 3-inch planks, as shown in Plate 6.

It will not be improper in this place to describe the machinery by means of which the materials required for the construction of the Tunnel were taken to the shield, and the excavated earth and drainage-water conveyed away. The Rotherhithe shaft was covered with a strong and substantial floor, upon which the thirty-horse steam engine already mentioned was placed. In the middle of the shaft was a strong timber framing extending from the top to the bottom, at the corners of which and connected with the steam engine were four plunger force-pumps, which were together capable of raising nearly five hundred gallons of water per minute. These pumps raised the water from the well already described, (Plate 3,) at the bottom of the shaft, and threw it into a culvert by which it was reconveyed to the river. During the early progress of the Tunnel, while the influx of water in the shield was inconsiderable, it was conveyed to this well by means of hand-pumps; but as the works proceeded under the river the influx was found to increase rapidly, until at last forty hand-pumpers were constantly required to keep the bottom of the excavation clear of water; the expense and inconvenience attending the raising of so large a quantity of water by manual labour, occasioned the erection of an horizontal suction pump at the bottom of the shaft, which was worked by the steam engine. A well was sunk in the lowest part of the Tunnel about six hundred feet from the shaft, into which the whole of the water from the shield was conveyed by means of a culvert formed under each arch, (which will be more particularly described hereafter,) and a suction pipe upwards of six hundred feet long was led from this well to the horizontal pump (technically termed the "dandy" pump,) by which the water was conveyed to the well at the bottom of the shaft, and from which it was raised by the four pumps already described. As these four pumps could raise a much larger quantity of water than the dandy-pump was capable of supplying them with, and as the quantity of water flowing into the shield (although that from the upper boxes was conveyed at once to the well at the foot of the shaft by a wooden shoot,) was sometimes so great as to overpower the dandy, a water-wheel was put up in the east arch, (worked by hand,) by means of which a large quantity of water could be raised into shoots, which conveyed it at once to the plunger-pumps whenever it was found necessary to do so. The whole of the water raised by the plunger-pumps passed through a 12-inch weir; and the height of the water flowing through the weir being taken by a floating gauge every half-hour, and registered in a book kept for that purpose, the exact amount of the influx of water into the works was always known, and any increase being immediately observed, gave a forewarning of any danger, and led to precautions being taken for the security of the works.

After some length of the Tunnel had been completed, the west arch was compoed and opened for the inspection of the public, but the east arch was still retained for the use of the workmen, and in this two lines of rails were laid down, one for the conveyance of bricks, cement, &c., to the shield, and the other for bringing away the excavated earth. These were placed in square boxes, termed skips, each of them containing about ten cubic feet, which were conveyed along the railway upon trucks, each truck holding two of the skips. As the Tunnel fell towards the middle, the trucks ran down the railway towards the shield by their own gravity, but were drawn up again by an endless rope worked by the steam engine at the top of the shaft. The skips were raised and lowered through a trunk within the timber framing (already described) in the middle of the shaft, by means of machinery in connexion with the steam engine; and as the descending skips were made to balance the ascending, very little power was expended in this part of the service. The skips containing the excavated earth were raised (by the lifting machinery) sufficiently high to allow of trucks being run under them, on to which they were lowered, being supported, or rather hung, by a pin a little above their centre of gravity; they were then wheeled off to a capacious receptacle by the side of the shaft into which the soil was emptied, by tilting the skips. The receptacle being placed sufficiently high to admit of carts coming under it, into which the earth was discharged through openings in its bottom.

As the length of the Tunnel increased it was found necessary to resort to some artificial means of ventilation, for which purpose a trunk was carried along the soffit of the arch, through which the impure air was drawn from the shield by means of two circular fan-blowing machines. Notwithstanding the use of which, during the summer months in particular, the air was so much contaminated by admixture with sulphuretted hydrogen and other deleterious gases evolved from the ground, as to occasion much sickness and inconvenience to the miners and others employed at the shield.

Two shields have been employed in the construction of the Tunnel, which although precisely similar in principle, yet differed from each other in many of their mechanical details. That which has just been described is the second or later one, as we considered it better to give the details of the machine in its most perfect state, and with all the additions and improvements which experience pointed out. As, however, nearly half the Tunnel was constructed with the first shield in its imperfect state, it will be proper to give also a brief account of the principal particulars in which it differed from the more improved machine already described. The old shield, in its exterior dimensions, was somewhat less than the later one, being only twenty feet six inches in height, thirty-five feet six inches in width, and occupying a space of little more than seven feet in advance of the brickwork of the Tunnel. It is in the last dimension that the principal difference exists, and the reason for increasing the shield in depth was to afford more room for the miners and bricklayers to carry on their respective vocations simultaneously and without interference. By increasing the width of the whole shield, it allowed of a larger space being left between the contiguous frames without encroaching on their size, those of the old shield having but a very small space between them, and only being preserved from actual contact by the insertion of wedges and small rollers. In regard of strength and stiffness the old shield was much inferior to the new one; and it must be borne in mind that it was proportioned by Sir Isambart for working through good firm clay, which had been reported and believed to exist entirely across the river, and was never designed for withstanding the almost irresistible force of the irruptions of loose ground to which it was not unfrequently exposed. But it was not so much in point of strength, as in the mechanical details that the old shield was inferior to the new one. In this respect the former was deficient altogether in four of the most important auxiliars of the latter, viz., the slings, the quadrants, the regulators, and the tie-bolt. The absence of the slings was the more a matter of importance as the legs of the old shield were very slender and weak, affording but a very imperfect means of support to the frames; and although stronger legs were afterwards substituted, they were continually bending and giving way, occasioning much delay and inconvenience from the sinking of the frames, which were sometimes so much below their proper level as to render it necessary to excavate more than a foot above the top staves, in order to preserve the requisite thickness of the crown of the arch. Another circumstance which caused the failure of the legs and increased the tendency of the frames to sink, was that the shoes bore directly upon the ground, which from their being of cast-iron, and rough on their underneath surface, adhered to them, not only making their bearing very uneven and irregular, but constantly breaking down and loosening the ground; and there being no universal joint (as in the new shield) to connect the shoe to the leg, the latter was often bent by the irregular strains thus produced. In the construction of the early part of the Tunnel no bottom planks were employed; but as much difficulty was experienced in obtaining secure foundations for the brickwork without them, their use was afterwards introduced, but being inserted behind the shoes they entirely lost the benefit of having the weight of the shield pass over them, and did not at all lessen the inconvenience which we have just mentioned of the ground adhering to the shoes.

The absence of the quadrants in the old shield was still more a matter of importance than that of the slings; for, as we have already mentioned, the frames having nothing to keep them apart, were frequently in actual contact, and being pressed together by the whole pressure of the ground upon both sides of the shield, were sometimes so completely jammed together as to make it almost impossible to move them at all, and rendered it necessary to employ such an enormous force to overcome the resistance thus occasioned, that the frames were not unfrequently fractured in being advanced.

Another point of much importance in which the old shield was deficient, was in the thin wrought-iron plates, already described as being attached to the tails of the top and side staves in the new shield, and which, by always overlapping the brickwork, left no portion of the ground without support. In the old shield these were entirely wanting; and it will be seen in the following section how much inconvenience and danger was occasioned in consequence. The top staves (of which there were three to each frame in the old shield) were not only inferior in this respect, but were also entirely destitute of the means of adjustment possessed by those in the new shield, there being neither saddles, swivels, nor ball-screws, nor any equivalent arrangement, in the former, but the staves simply resting upon a flat plate at the head of the frames; and although the great inconvenience resulting from this circumstance was very soon perceived, and caused an arrangement being adopted which admitted of a slight means of adjustment, yet this was very imperfect and limited in its action when compared with the new shield. Indeed it is almost a matter of surprise how so great a rate of progress should have been attained, through excessively loose ground, with such comparatively imperfect means of supporting the ground, as that afforded by the first shield.

SECTION III.

CONTAINING AN ACCOUNT OF THE PROGRESS OF THE TUNNEL FROM ITS COMMENCEMENT, UNTIL THE STOPPAGE OF THE WORKS AFTER THE SECOND IRRUPTION.

In the first section we gave an account of the process of sinking the Rotherhithe shaft, the narrative being brought down to its completion. Previous however, to proceeding with a description of the further progress of the work, it was deemed essential to describe the shield,—the machine by means of which the excavation was carried on, and to give an account of the manner in which it was employed in the formation of the Tunnel: this having been done at some length, in the preceding section, we shall now proceed at once to give an historical sketch of the continuation of the works, noticing every incident of any interest or importance which occurred in the progress of the shield during its subaqueous passage under the Thames.

It has already been stated in the close of the first section, that the bottom of the shaft was sufficiently completed by the middle of October, 1825, to allow of the several parts of the shield being lowered, and put up in their places, in front of the opening, which had been left in the wall, for its passage out of the shaft. This opening was, however, found not to be sufficiently capacious; and in consequence of the Tunnel being commenced at a higher level, by nearly five feet, than had been originally intended, a considerable mass of brickwork had to be cut away at the upper part of the opening; and it was also found necessary to remove the segments of the cast-iron curb, on that side, to allow the top staves to pass. For the purpose of effecting this, and of facilitating the passage of the shield out of the shaft, as well as to afford the means of more perfectly connecting the Tunnel with the shaft, and making good the ground round the line of juncture, three small wells, (shown at *a*, *b* and *c*, Fig. 1, Plate 12,) were made close to the wall of the shaft, on the north side, and carried down to the stratum of clay, (*g*, Plate 3,) at which level, headings were made round the wall of the shaft, from one well to the other, as shown by the dotted lines. In order to reduce the column of water round the shaft, and render the ground through which the head of the shield was to pass as dry as possible, a number of pipes were inserted through the wall, above the opening, and the water from them was led by troughs into the well at the bottom of the shaft.

By the middle of November, the whole of the shield had been lowered and put together, ready for operation so soon as the plates of the curb should have been removed: this having been effected by the latter part of November, the frames were started, and by the end of that month had been advanced two feet, and had just entered the ground at the corners, the polings having been substituted for the temporary blockings in some of the frames. The progress of the shield at this period was necessarily very slow, from the great difficulty experienced in obtaining a sufficiently firm abutment for the screws by which the frames were advanced. Sir Isambart, in a report to the Directors[a], observes, "Before the shield could be applied against the ground for its support, shores and abutments were set up against each frame, and others were provided to secure a portion of wall that was to be removed, and these were afterwards extended beyond the wall of the shaft, to support the ground. It is to be observed that at every move of each frame, that is, at every four or five inches of their progress, new blockings were set up, and those in front were reduced in equal proportion; purchases being taken from several points, to guard against accidents, which in an enteprrise of this nature would inevitably have been attended with the most serious consequences. No move, or alteration of position, could therefore be made without extreme precaution, and consequent attention to every object connected with the operation. It must be recollected, I invariably expressed that I considered the getting out of the shaft and securing the work quite into the undisturbed ground as the most difficult point to be overcome, considering that the men, by whose agency this was to be effected, were totally unacquainted with the instruments that were to be used, and that too under the most disadvantageous application that can be imagined. No provision could be devised to qualify at once the roughest quality of men, such as miners, excavators, bricklayers, and labourers, for the management of a machine of such complication in its parts, and of such nicety in its movements, as the shield is." The miners in particular, being totally unused to machinery, and unacquainted with the nicety required in the systematic and regular advance of the shield, soon got the frames out of level, and by running the abutment screws too far out of their boxes, had stripped many of them of their thread, and rendered them useless.

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[a] Dated 17th, January 1826.

By the 20th of December, however, the shield had been advanced nearly five feet, leaving a sufficient space to allow of the brickwork of the Tunnel being commenced behind it. The shield had up to this time been supported by temporary timber blockings, and these being now nearly five feet thick, consisting of as many as eight or ten thicknesses of timber laid upon each other, formed an abutment of such an elastic and yielding nature, that it was not deemed safe to take any support for the brickwork from it. As the arch progressed, it became necessary to remove these blockings, and the structure being still too weak to allow of any abutment being taken against it, fresh blockings had to be inserted for the support of the frames. With great precaution, the double arch was made three feet thick at once; but not considering it safe to take an abutment for the shield against it, until a greater thickness had been made, and the work had had more time to set, the frames were with great care advanced two feet more, and this additional thickness added to the arch. To render the first portion of the brickwork stronger, and to secure a more perfect junction with the walls of the shaft, the side piers were increased two feet six inches in thickness; and as for this purpose the ground had to be excavated to that depth, beyond the side staves, on either side, considerable difficulty was experienced in effecting it; and Sir Isambart remarks[a], "I have no hesitation in stating, that more time was taken for making that additional thickness of brickwork, than for constructing an equal length of the arches." This increased thickness in the side piers was continued for about the first twelve feet in length of the Tunnel, after which the true form of the arches was commenced.

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[a] Sir I. Brunel's Report to the Directors, dated January 17th, 1826.

Notwithstanding all the precautions which had been taken, the arch upon the west side was cracked by the abutment screws, and from the inexperience of the men in the use of the shield, the frames had already become very much out of level, especially No. XII., which, in consequence of a slip in the ground there, (occasioned by having to excavate beyond the side staves for the purpose of thickening the side pier,) had sunk ten inches below the other frames.

By the 20th of January, 1826, notwithstanding the inexperience of the men in the use of the abutment screws, and the frames being jammed together by the excessive lateral pressure, the body of the Tunnel had been completed to a length of 12 feet, and the arches were commenced of their true form. The ground was found very loose and wet in the middle frames, and in working out beyond the side staves, the ground again gave way and fell in; in addition to which a large body of water was met with which proceeded from the land springs in the middle frames. "On Wednesday night [the 25th], we had succeeded in stopping the whole of this water from the frames, and in rendering the superstratum of clay completely dry in the middle, as it had been for some time at the sides, when the water broke out again over the frames Nos. IV. and V., which is near the place where we had a well and a heading. The sides being now considerably ahead of the ground which had been disturbed by similar operations, are perfectly dry and sound, notwithstanding the several slips of ground which have taken place when the excavation was making in that part of the work."[a] The water also broke in with great violence over Nos. VIII. and IX., and upon probing, the ground was found to consist entirely of gravel and sand. In order to divert the water, and substitute puddled clay for the loose ground, a heading was commenced from the east well, c, Figure 1, Plate 12, and carried horizontally over the shield about seventeen feet; but as this did not produce any beneficial effect, it was determined to suspend the progress of the shield, and to sink a well from the surface down to the level of the disturbed ground. On the 3rd of February a brick well, seven feet nine inches in diameter, was accordingly commenced directly over Nos. VI. and VII., and about nine feet six inches from the side of the shaft, as shown in Figure 1, Plate 12. By the 8th the well had been sunk within two feet of the stratum of clay, *g*, Plate 3, when the ground was found very much disturbed, the clay being broken away and entirely replaced by gravel, through which some difficulty was experienced in continuing the process of sinking, and it was found necessary to proceed with the well by underpinning.

February 11. On further probing the ground, it was found that the clay had broken away to a very considerable extent, leaving a space somewhat of the form shown by the dotted line, *d*, *d*, which was filled with the loose gravel from above, and from which the principal influx proceeded. As, however, the well approached the frames, the quantity of water diminished, and the advance of the shield was resumed.

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[a] Sir I. Brunel's Report to the Directors, dated 31st Jan. 1826.

In describing the old shield, we mentioned that each frame had three iron top staves resting upon a broad plate, which formed the head of the frame. But in consequence of these staves not having been completed in sufficient time to be put in their places before the starting of the shield, as a temporary substitute, a number of planks, eight inches deep and between three and four inches wide, were laid close to each other, edgewise, upon the head of the frames, as shown in Figure 1, page 25; and these, in addition to the excessive pressure upon them, having become sodden by the water, and very much deranged in some of the frames, much difficulty was experienced in putting them forward: besides which, there being no quadrants in the old shield to keep the frames from coming into actual contact, the friction between them was found to occasion a considerable resistance to their being advanced, for the purpose of lessening which rollers were inserted between them.

February 16. The water continuing to come from the middle frames, and having burst in with some violence over No. V., a pipe was let into the brickwork behind No. VI., for the purpose of diverting it from the front, and leading it to the back of the frames, which was found to have the desired effect.

March 1. Many of the temporary wooden staves were considerably deranged, and the whole shield was found to be 7½ inches too far to the west.

March 6. In consequence of the great quantity of water at the back of No. VIII., a thin plate or tail was provided for the top staves to overlap the brickwork; but during the night of the 11th, this excessive influx from the back part of the frames was entirely stopped. The Tunnel had now been completed to a length of 29 feet, and up to this period the brickwork had been constructed in 3-inch rings, or with bricks flatwise; but this method of building being found inconvenient, occasioning a larger consumption of cement, the brickwork was ordered for the future to be made in 4½-inch rings. Up to this time no record of the weekly progress of the Tunnel had been kept, as the work had been interrupted by so many fortuitous circumstances that the advance of the shield had been extremely irregular. But the men having now acquired more experience in the use of the shield, and the excessive influx which had for so long a time retarded the work having been completely stopped, the advance of the shield became more regular, and from this time a record was kept of each week's progress.

March 14. The ground, which was very loose upon the east side, fell in, and also at the west corner, but the latter was owing to bad management.

March 17.
Weekly progress 7 0
Length completed 36 0

March 21. Another very considerable slip of ground took place at the east corner. The wooden top staves were so much deranged that the new ones of iron were ordered without delay.

March 24.
Weekly progress 8 0
Length completed 44 0

March 25. The ground again broke in at No. XII.—these repeated slips were caused by the frames being 18 inches too far to the westward, which occasioned the necessity of excavating the ground to that extent beyond the side staves, for the purpose of preserving the requisite thickness in the east pier.

March 31.
Weekly progress 5 5
Length completed 49 5

April 2. In order to facilitate the progress of the frames, the chaces of the legs were chipped out by Maudslay's men, to allow of a greater action in the legs. Much illness existed at this period amongst the men.

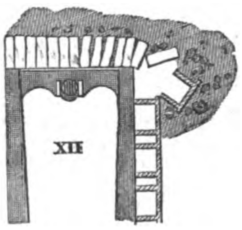
April 7.
Weekly progress 9 3
Length completed 58 8

The ground was not quite so dry and firm as it had been, and contained a larger portion of silt.

April 14.
Weekly progress 8 9
Length completed 67 5

April 21.
Weekly progress 8 0
Length completed 75 5

The wooden top staves in No. XII. were forced out of place and crushed by the excessive pressure; and the top side stave was also much deranged, as shown in Fig. 1 in the margin, in consequence of which new top staves were substituted in that frame, and also in No. VIII.



April 25. The ground was found to be settling in Rotherhithe Street, under which the shield had passed a few days previously, although the depth of ground from the surface of the street to the top staves was not less than 38 feet. This circumstance will serve to show the great pressure to which the top staves must have been subjected by the settlement of such a considerable weight of ground upon them.

April 27. The legs, the action of which had been increased from 3 to 6 inches, were found jammed, and bent in consequence.

April 28.
Weekly progress 9 0
Length completed 84 5

The frames having a tendency to separate at the upper part, it was found necessary to tie them together with a chain.

May 1. The progress of the work was very much retarded by having to excavate beyond the side staves in No. XII., for the purpose of building the east pier; the whole shield being still 18 inches too far to the west. The ground above the shield continued to settle to such an extent as to occasion a considerable crack in the wall of one of the houses in Rotherhithe Street.

May 3. One of the legs broken:—while the movements of the legs were limited to 3 or 4 inches, they were found to be sufficiently strong, and no complaints were made of their giving way; "but so soon as their action was increased by lengthening the chaces, one of the legs gave way, and the whole set, twenty-four in number, gave way one after the other in a very few weeks."[a] The frames of the shield were considerably out of the perpendicular. The brickwork was found to be very irregular and much out of the correct line; it was therefore ordered for the future to be built with bricks endwise, or in 9-inch instead of 4½-inch rings.

May 5.
Weekly progress 11 0
Length completed 95 5

May 10. The frames were advanced too far ahead, leaving 20 inches of ground unsupported; a most dangerous practice, since it will be recollected that in the old shield there were not any tail plates to secure the ground behind the staves. Another leg was broken and several others found strained.

May 12.
Weekly progress 10 0
Length completed 105 0

May 18. The whole of the preceding week was occupied in inserting new iron top staves under the wooden ones, during which operation an additional settlement was observed in the house in Roherhithe Street. The whole shield was found to be 2 feet 3 inches too far to the west. A slight crack was observed in the middle pier; it should be observed that no foundation planks were used in the first portion of the Tunnel, but that the ground was beaten with a dolly to compress it, previously to the brickwork being built. Up to this time the foundations and invert had always been carried up simultaneously with the upper portion of the work, and had been built in either 3, 4½, or 9-inch rings accordingly; it was, however, ordered for the future to be made in 18-inch rings, which method of building admitted of much sounder work.

May 22. The head of No. I. cracked with a loud report, without any perceptible cause. This circumstance is sufficient to show the enormous strains to which many parts of the shield were exposed; this was the first fracture of any importance which had occurred.

May 26.
Weekly progress 8 11
Length completed 114 4

June 2. The frames were still very much out of the perpendicular, half of them leaning to the west, and the other half to the east.

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[a] Report of Sir I. Brunel to the Directors, dated 20 Feb., 1827.

June 4.
Weekly progress 7 4
Length completed 121 8

The whole shield being still 2 feet 3 inches too far to the west, which occasioned considerable inconvenience and delay, from having to excavate nearly to that extent beyond the side staves of No. XII., whenever it was necessary to build the east pier, it was determined to make a heading outside that frame, for the purpose of moving the whole shield bodily over to the eastward. This was accordingly commenced, by removing the side staves (one at a time), and having excavated the ground to a sufficient depth, replacing and firmly strutting them against the ground, as shown in Fig. 3, Plate 12.

June 7. This having been successfully accomplished, and the whole of the side staves worked out to the required distance, the frame of No. XII. was next moved bodily over and placed against them, and the whole of the other frames in regular succession; No. I. and its side staves being brought up close to the other frames. Although this was an undertaking of peculiar hazard and difficulty, from the great weight of the frames and the confined situation in which the operation had to be carried on, it was successfully accomplished without any accident, and did not occasion more than a week's delay. In consequence, however, of the stoppage of the works the ground was found to have become very loose, particularly in Nos. III., IV., and V., in which frames it cracked to such an extent that it was found necessary to drive flat pins horizontally into the ground at the floor-plates for the purpose of supporting it.

June 9.
Weekly progress 0 0
Length completed 121 8

June 16.
Weekly progress 6 0
Length completed 127 8

June 21. Much delay being occasioned by the repeated failure of the legs, a new set of stronger ones was ordered. Long rollers were inserted between the frames for the purpose of lessening the friction as much as possible.

June 23.
Weekly progress 6 6
Length completed 134 2

The frames too much to the eastward. The shoes were shortened 7 inches in front, as in consequence of their being too long they were found to break away the gravel at the lower part of the bottom faces.

June 30.
Weekly progress 8 11
Length completed 143 1

Very great inconvenience experienced from the legs giving way, four of the frames being supported on timber props; and the top staves were found to be sinking from the same cause.

July 4. The brickwork was found crushed at the fifth doorway; and the infiltrations through it increased, owing to the inferior quality of the cement. Orders were given for the Tunnel to be built in 4½-inch rings.

July 7.
Weekly progress 6 1
Length completed 149 2

The small advance made this week was in consequence of the time occupied in substituting new legs in many of the frames in which the old ones had given way. In order to obtain a higher rate of progress than that which had hitherto been attained, the Directors determined upon trying a system of piece-work, under which the miners and bricklayers were to be paid in proportion to the length of Tunnel completed weekly. It will be seen by the marginal record of progress, that a considerable acceleration in the work was the *immediate* result of this arrangement; but this state of things did not continue long, and it was soon found by experience, and by the *subsequent delay* of the work, that this system of recklessly pushing on, without regard to existing circumstances, but sacrificing every thing to obtain an inch or two more, was not that upon which an undertaking of this description could be safely or advantageously carried on.

July 14.
Weekly progress 11 0
Length completed 160 2

The top plate of No. XI. was broken in two places, and it became necessary to support it by wrought iron struts. A separation took place in the ground at the top corner of No. XII., as shown at A, Fig. 4, Plate 12, to a depth of upwards of 2 feet 6 inches, the silt dropping down from the clay, which remained unsupported; common mortar and some small stakes of wood were introduced without any force, merely to fill up the cavity.

July 20. The silt was found to adhere to the top staves, not only occasioning a very great impediment to their being advanced, but also disturbing the ground. In order to obviate these inconveniences, puddled clay was inserted at the point of the staves for the purpose of lubricating their upper surface. No. XII. was in a very bad state, the points of the side staves diverging more than 6 inches to the east, in consequence of which the ground frequently fell in. Although at the upper part of the excavation the ground was very firm and dry, the gravel in the lower faces was found to be extremely loose.

July 21.
Weekly progress 11 0
Length completed 171 2

July 24. The new legs having been put in place in all the frames were found to answer perfectly. The ground again slipped down at No. XII. to such an extent that above a thousand bricks were required to fill the cavity. In consequence of the frequent breaking in of the ground at the tails of the side staves, occasioned by their divergence, and also by the want of support, it was determined to build a 9-inch wall against the ground, outside the side staves, from the bottom to the top of the excavation, as shown in Figure 4, Plate 12, the bricks being inserted at A, the points of the side staves, when the faces were worked down. And this system of side bricking was found to support the ground so securely at No. XII., that it was also adopted at No. I.

July 28.
Weekly progress 9 0
Length completed 180 0

The ground still continued of a silty nature above the top staves, and occasioned considerable trouble by adhering to them, by which it was so much broken and disturbed when the staves were advanced, as to occasion it frequently to fall in at the tails. In addition to which, the resistance which it opposed to the advance of the top staves, required so great a force to be applied to overcome it, that the head of No. X., besides many other frames, had been fractured from this cause. To lessen the evil as much as possible, the top staves were ordered to be advanced separately.

August 4.
Weekly progress 12 0
Length completed 192 2

On the 5th of August, Mr. Armstrong, the resident engineer, whose health had been for some time seriously affected by the peculiar nature of the employment, was seized with a dangerous illness, by which he was quite incapacitated for the performance of his duties, and Sir Isambart was from this time altogether deprived of his services.

The gravel was very loose and flowing in all the lower faces, and also in the upper ones of the eastern frames, and although extremely bad with much water at the bottom corner of No. XII., the side bricking was found to afford a complete protection. A boring having been made in the upper part of No. X., which was driven forward twenty-five feet into the ground, it was found to consist entirely of silt; no water was, however, met with. The head of this frame was very much damaged by a second fracture, occasioned by the resistance of the ground; and the head of No. XII. was also fractured from the same cause. Although the system of piece-work had been in operation little more than a month, the shield had become completely deranged, the frames were all out of level, the legs were jammed to such a degree that five or six men were required with a tackle to relieve them, and the heads of almost all the frames were broken in one or more places. This disorganized state of the whole shield was occasioned by the reckless manner in which it had been worked by the men, whose only object was to carry on as fast as possible, (to obtain greater pay,) utterly regardless of the inevitable consequences which must and did ultimately result from it, and which occasioned to the Company a far greater expense in the repairs of the shield and the subsequent delays, than the small saving in wages which had resulted from the temporary acceleration of the work. Sir Isambart says, "In considering the serious consequences that have resulted from the want of a competent person to superintend the movements of the shield, upon which everything depends, I have engaged an engineer, Mr. Gravatt, who will devote his whole time to the shield and machinery, and be considered responsible for their good order and security."[*]

August 11.
Weekly progress 12 6
Length completed 204 8

August 18.
Weekly progress 12 6
Length completed 217 2

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[*] Report of Sir I. Brunel to the Directors, September 5th, 1826.

August 25.
Weekly progress 12 6
Length completed 229 8

The character of the ground remained unchanged; in the lower faces very loose, and in the upper ones silt remarkably firm, which although it afforded a good protection to the head of the shield, occasioned much resistance to the advance of the staves. The heads of most of the frames had been broken in two, and were only held together by stanchions; and the whole shield was very much out of level, Nos. IV. and IX. being too low and No. VII. much too high.

September 6.
Weekly progress 12 6
Length completed 242 2

September 7.
Weekly progress 11 0
Length completed 253 2

On the 8th of September, about 2 P.M., a separation was observed in the ground (consisting of silt) above No. XI., between the staves and the brickwork, from which a small stream of water issued. The ground being without support, became softened by the water, and soon ran in a stream of diluted silt; this was checked for a time, by forcing oakum and clay up between the staves, but in about two hours it again made its way, and commenced running at No. VIII. A similar remedy having been adopted, it was again almost entirely checked; but in attempting to forward No. VII. during the night, it again burst in at the back of that frame with greater violence than before, and the run increased to such a degree, that it became necessary to introduce wedges between the staves of Nos. VII. and VIII., to keep the oakum and clay in place and prevent their being washed out by the water; in addition to which, planks and struts were placed at the tail of the stave to support the ground where the run had first commenced. Mr. Brunel was in the shield superintending these operations during the whole of the night.

September 9. On the following day, "in attempting to advance No. VI. the water and silt came down with so great a force, as to require the united exertions of three men to introduce and retain the necessary stuffing between the frames of Nos. V. and VI., and VI. and VII. Notwithstanding, No. VI. was advanced amid this inundation, after which there was a cessation for a time of both silt and water. On its reappearance its character was evidently changed; the clay being now loosened by the water, began to run; but as it gradually thickened, I was led to suppose that it would soon form an impervious puddling upon the top of the staves, in which I was not disappointed. Thus the silt being washed away, the lower stratum of clay was loosened, which not finding an immediate vent, allowed the superstratum to come gradually down and close the fissure against the influx of the water. Measures were now taken to advance No. VII. frame, which was accomplished with comparative facility, and the brickwork carefully brought up."[a] Mr. Brunel, who superintended these proceedings, remained down in the works during the whole of the day and night.

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[a] Report of Sir I. Brunel to the Directors.

September 11. The water still being very abundant over No. VI., the greatest caution was used in advancing the contiguous frames; but on endeavouring to forward No. VI. itself, the water increased to such an alarming degree, bringing down with it large quantities of crumbly clay, that it was determined to leave the top staves, both of that frame and also of No. VII., behind, and to build them into the brickwork. With this intention the other frames were advanced, the brickwork brought up close behind Nos. VI. and VII., and a heading commenced in front of those frames, as shown in Figure 1, Plate 13, the roof or ceiling of which was composed of pieces of timber eight inches square, bearing about five inches at each end on the contiguous frames; these were covered with three inches of strong yellow clay, and forced up into their place by screw jacks, the joints between them being securely caulked with oakum, so as to form a covering perfectly impervious to the water.

September 12. While this was being proceeded with, the water from Nos. VI. and VII. increased to an alarming extent, bringing in with it gravel and small particles of broken clay in such quantity that a large cavity was left in the ground, above the top staves of those frames, into which, about 3 p.m., the superincumbent earth fell with a shock like an earthquake. The ground above the Tunnel having been thus disturbed, the water from the river made its way through it, and poured in between the top staves with increased impetuosity, forcing out the battens and oakum, which had been driven in to stopit. In the hopes of diverting the water, and to prevent the ground in the faces from being washed away, two holes were cut through the spandril of the middle pier behind Nos. VI. and VII., and after probing the ground two or three times, a considerable flow of water was at length obtained through them by which the faces were immediately relieved, and the influx in front very much diminished; after running through these holes for some time it suddenly stopped, but shortly afterwards again made its appearance, accompanied by a rumbling and gurgling noise occasioned by the settlement of the ground overhead. Sir Isambart remarks in his report of the occurrence, that "during the whole of this eventful night it was truly gratifying to see the perfect confidence displayed by the workmen, many of whom I observed sound asleep in the bottom cells."

September 13. Things had slightly improved in the shield. Iron pipes were inserted in the holes which had been cut through the spandril behind Nos. VI. and VII., and the quantity of water coming through them was measured, and found to amount to ten gallons per minute. The heading in those frames was proceeded with, and the gravel in the faces being found very loose, puddled clay was inserted in front of the poling boards to prevent its being disturbed and washed away.

September 14. The water which continued to flow from the pipes in the brickwork was found undoubtedly to come from the river, not only from its temperature, but also from the quantity being less at low water than at high; for being measured at high water it was found to amount to eight gallons and a half per minute, at low water only six, and at the succeeding high water (being an unusually high tide) ten gallons. Whenever the influx was found to diminish to any extent with the fall of the tide, or to increase with its rise, it was regarded as a sure indication that the water proceeded from the river, for it was generally found that the influx from the land springs was rather diminished in quantity than otherwise by an increased tidal pressure.

September 15.
Weekly progress 4 0
Length completed 257 2

The heading having been carried on in advance of Nos. VI. and VII., as shown in Figure 1, Plate 13, sufficient space was gained to remove the top plate or cap of No. VI. The ground still preserved its character, being very good and hard in the top, but in the lower faces being extremely loose, the gravel flowing like quicksand.

September 16. As the heading proceeded, the quantity of water from the pipes diminished, being reduced at high water to only six gallons per minute; but in the evening a circumstance occurred which showed the importance and necessity of providing a free vent for the water, for one of these pipes having become accidentally choked, the liquid silt and water soon made its appearance between the staves of No. VI.; but the pipe having been cleared, the run of silt immediately stopped, and the water was again diverted into its former channel.

September 17. The work was continued during the whole of Sunday, as from the loose nature of the ground it was not considered safe to suspend the operations in the shield even for one day.

On the 19th, owing to the carelessness of one of the miners, the ground in Nos. XI. and XII. fell in to a considerable extent. Upon the whole the quantity of water from the frames was not found to be greater than before the run in Nos. VI. and VII., since one hand-pump in the bottom frame was found sufficient to keep the excavation free from water. The ill effects of the system of piece-work in any undertaking of this nature was now very clearly evident, for the shield was in so deranged a state, that it was found impossible to make any rapid advance with it. The lower abutment screws, from having had too great a force applied to them by the men, who were only intent on their present progress, and utterly regardless of future consequences, had been spoilt, and completely stripped of their thread; and being thrown on one side, had become buried in the rubbish, their place being very inadequately and insecurely supplied by jacks. The legs were also jammed, and the

No. IX. Nearly in the same state, and one ring of the brickwork having gone, the frame is fallen back as much.

No. X. The same, and one more ring gone.

No. XI. The same.

No. XII. The bags in front have closed more, and No. XIII., (as we call it[a],) is nearly closed. The water is coming from the front now; the bags behind apparently in the same state as yesterday."

The soundings upon the river still showed the ground to be settling; every fresh tide discovering a depression in some part of the covering, and obliging the necessity of throwing over large quantities of gravel and clay. The quantity of water in the frames was found to vary greatly with the state of the tide, averaging only about 280 gallons per minute at low water, but increasing to 450, and becoming muddy at high water. On the 4th of July a temporary centre having been put up, the rings of brickwork which had been disturbed by the violence of the irruption, were rebuilt, by which the condition of the eastern frames was rendered much more secure. Nos. II. and III. being cleared of ground, every thing was found in good order in front, and what was rather remarkable, although the polings were all in place, and not at all displaced, the natural ground in front of them was found entirely replaced by bags, which had thus made their way in front of the faces, without causing any derangement in them.

On the 5th, the whole of the men came up with the account that the water was increasing very considerably at No. XII.; in consequence of their quitting the frames, Mr. Beamish went to the shoots, but finding no sensible increase of water there, he set the example to the men, who followed him back to the shield, and continued to work well while he watched the run; notwithstanding, however, their exertions, the ground ran in at the back of Nos. X. and XI., although every precaution had been taken in shoring it up. This run produced a sensible derangement or movement in the ground, which having opened fresh ways for the water, and the tide being at the time unusually high, the influx increased considerably; and although at one time it overflowed the shoots, and the men in case of emergency had no other means of escape but the boats, they still, with great resolution, continued at their several posts. Sir Isambart remarks upon this occasion, "If we reflect that the only way to get to the frames is with a boat, it is truly awful to think how the men reconcile themselves with danger. The example set to them is the stimulus. What a man would shrink from when left to himself, he will face when acting before others." A similar, but much more alarming increase in the influx took place about the same hour upon the following day (July 6). Mr. Brunel and Mr. Beamish, with some of the miners, were in the shield about high water, when an immense volume of water, amounting to about 1,200 gallons per minute, suddenly burst into No. XII. with such violence that one of the miners who had charge of the boat, becoming terrified, jumped into it, and utterly regardless of the safety of the others, pulled the boat away to the shaft, and immediately she grounded, ran up the stairs, without stopping to look behind him, leaving those at the shield in the most perilous situation, for had an irruption taken place, being thus left without any means of escape, they must all have been inevitably lost. The men, however, behaved with great resolution, and under Mr. Brunel's direction, applied boards to the front of the frame, in the hope of blocking it out; but in spite of all their efforts, the water continued to increase, rushing into the frame with a hollow roaring noise, and forming a series of fine cascades, as exhibited in the annexed sketch, which in any other situation would have called forth their admiration, but in the perilous position in which they were left, served only to increase their fear and anxiety. Fortunately, however, some of the more resolute of the men brought the boat back, when they all left the shield, and were not permitted to go down to it again until the influx had in a great degree subsided, which it gradually did as the tide fell, and at low water did not amount to more than 650 gallons per minute.

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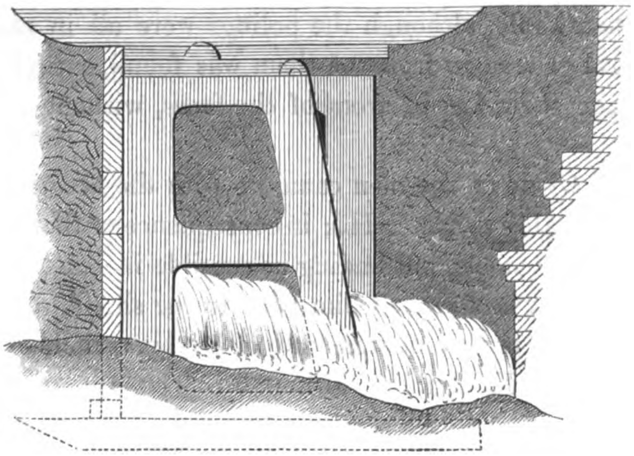
[a] The frame having been for some time previous to the irruption too far to the west, the side bricking and staves at No. XII. had been kept away from the frame, in order to preserve the requisite thickness in the east pier, and the space thus left was designated No. XIII.



On the 7th a tarpaulin, forty feet square, was spread over the covering, and two barges of gravel were thrown over it. Mr. Brunel superintended the operation in the diving bell, and descended several times, to ascertain that it laid properly; on one of these occasions he had an almost miraculous escape, for while down in the bell, the chain by which it was suspended slipped through the stoppers, but most providentially jammed itself tight before being all run out, otherwise the consequences must have been fatal. On the 11th, a much larger tarpaulin, eighty feet square, was laid over the covering; it was sunk very evenly into its place by loaded chains attached to the edges, the total weight of the tarpaulin and chains being about nine tons. The water at the east corner somewhat changed its position, and shifted to Nos. X. and XI., from the former of which a run of ground amounting to about two skips-full took place; it was, however, soon checked by cutting off all communication with the contiguous frames. On the 13th, they commenced pumping the water from the Tunnel, in which it was still level with the top floor plate, or within four feet of the crown of the arch. A rather considerable run of gravel took place (July 14) from No. XII., and also a run of silt from Nos. II. and III.; a large cavity was found at the back of Nos. X., XI., and XII., which was filled in with straw and clay, until the water ran clear. Notwithstanding these runs in the ground, the influx had regularly and gradually decreased since the tarpaulins had been laid over the covering; their beneficial effect in this respect is very decidedly shown in the following table of the quantity of water flowing into the shield at high water of each day for the preceding week :—

July 8.	The influx amounted to	850	galls. per min.	—Small tarpaulin laid down.
„ 9.	ditto	625	„	
„ 10.	ditto	600	„	
„ 11.	ditto	530	„	The large tarpaulin put down.
„ 12.	ditto	500	„	
„ 13.	ditto	430	„	
„ 14.	ditto	360	„	

On the 17th, about 11 A.M., while attempting to work down No. XII., a quantity of gravel suddenly fell in, with so great a noise, that the miners became alarmed, and made for the boat; finding, however, that it was not followed by much water, they returned; but Mr. Gravatt, who was in the shield at the time, considered it prudent to defer any further operations until low water, at which time it was again attacked, and although the gravel rattled down with considerable violence, they succeeded in working down the face, and rendering every thing perfectly secure. The disposition of the ground in this face was rather singular, there being three distinct layers or strata of bags, with a vein of gravel about six inches thick between them, which ran out when the face was worked, and the bags being too firm to follow, a cavity was formed, which was filled in with tempered clay. A boring being made in this box, silt was found at seven feet, but the strong blue clay was met with at fifteen. The influx had decreased to only 200 gallons per minute. The polings having now been restored in the whole of the top boxes, and the faces additionally secured with face planks and struts, the clearing of the middle faces was next commenced upon; but as they were completely buried in the ground, it was necessary to make a dam across the arches, a few feet back from the shield, in order to support the ground as the excavation was carried down.

A laughable incident which occurred upon the 21st, shows how susceptible of alarm the men were at this period; being Saturday evening, there were only two or three watchmen at the shield, when Rogers, (one of the miners,) who was standing at the edge of the water in the west arch, was suddenly alarmed by hearing one of them calling for clay, wedges, &c., exclaiming that the whole of the faces were coming in together. Having collected some wedges, and found a small boat in the east arch, he soon reached the shield, but could not find anybody in the frames, nor any appearance of derangement in the ground. He called to the men, but received no answer; fearing that they might be drowned, he explored farther and saw them, (four in number,) stretched on the small stage, not drowned, but fast asleep. Another false alarm was occasioned a few days afterwards; some new shoots had been put up for conveying the water from the shield, to the well at the foot of the shaft, and upon turning the water into them, three of the last fell down, causing of course a tremendous crash; the pumpers immediately jumped pell mell into the water, and the miners flew to the boats, but the alarm was soon turned into a laugh; nevertheless this might have produced serious inconvenience if visitors had been present.

By the 26th of July, the water was so much lowered that they were enabled to reach the frames without a boat; and on the 28th the Tunnel was again lighted with gas, and visitors were admitted to the west arch as before the irruption. The clearance of the middle boxes was continued with extreme caution, notwithstanding the excellent nature of the ground, and every precaution was taken to prevent the frames receding, for which purpose a balk of timber was placed across each arch to secure the lower floor in case the frames should be found without abutment at the bottom. A remarkable break or crack in the ground, several inches wide, was found running through the middle faces of Nos. I., II., III., and IV., in a sloping direction; it was filled by driving in tempered clay. In proceeding with the clearance of the shield, several even of the lower faces were found considerably disturbed; in No. I., five of the polings were gone, and the ground ran in from above; in No. IV., three of the polings had been carried away, and the ground at No. XII. was so loose and bad, that it was found necessary to drive clay and straw into the front and side of it, to fill the holes which were met with. The shield having been thus entirely cleared, they were enabled to ascertain the precise amount of damage caused by the irruption, and we cannot do better than transcribe Sir Isambart's report to the Directors upon this subject:—"I have the honour to lay before you an account of the present state of the works of the Thames Tunnel, which I am now fully enabled to do, as the soil has been completely removed, and every part of the works exposed, and capable of being minutely examined.

"It has been already stated, that neither the safety of the shield or the brickwork have been affected by the late irruption; this statement, our subsequent observations fully confirm: but, as so prodigious an irruption could not have taken place without producing some derangement, I shall in succinct terms lay before you a detailed account.

"The brickwork at the top of the east arch being immediately exposed to the violence of the water, and being but recently completed, was, to the extent of three rings, washed away; the surface of the corresponding invert was also torn up for some feet, leaving the interior part, however, perfectly sound. The bottom of the east pier was for a short distance considerably damaged, which, together with the invert, have been restored without difficulty.

"Owing to the three rings of brickwork being disturbed in the east arch, those frames which received their support from them moved backwards, until they again met the brickwork behind.

"On the east side the ground ran in, or became so soft, that the natural lateral support was taken from the east frames; this has in consequence made them incline over, and move sidewise about a foot, until checked by the ties which hold the body of the frames together; another consequence of the displacement of the ground was the removal of the side staves, which, owing to the extraordinary changes that had taken place, have been dispersed, and some of the wood-work attached to them actually floated to the surface of the river; four have been found in the front of Nos. VIII. and IX., and one felt at the back of the east pier; the bottom one, with a portion of the side brickwork, remains in place.

"Nos. VIII. and IX. frames have each received some injury, viz., the front rail of the one and back rail of the other being broken; but as these parts do not affect the real strength of the frames, and as similar derangements have occurred before, and were easily rectified, I cannot consider the circumstance of any material consequence. The outside leg of No. XII. is also broken, and the floor-plate strained, but no difficulty presents itself in the repair.

"The force of the water was so great, as to wash away not only the stage in the east arch, but all the timber work of every description, and yet has had no effect whatever upon the brickwork, further than what I have already stated. Owing to the constant passing and repassing of the boats to and from the frames during the time that the water was permitted to remain, the stucco of the finished portion of the west arch had been injured, but is now restored.

"The only delay we experience is in replacing the east frames upright, and which must of necessity prove a work of time, as it can be only performed to each frame in succession. The operation has commenced at No. VI., where we have had an opportunity of proving the extraordinary consistency and density of the newly formed ground, and which has added more and more to the confidence and spirits of our men.

"Horizontal borings have been made to the extent of fifteen feet in front, which, after passing through six feet of the new ground, and about eight feet of the strong silt, enter the clay; these borings, together with the appearance of No. VI., where the most difficult part of our operations have already been accomplished, prove the strength and goodness of the ground. Prickings and soundings have been made all across the river, and no appearance of any further defect, either natural or artificial, in the bed can be discovered, and I flatter myself the borings now in progress will afford additional proof of the consistent nature of the strata above our heads."

The state in which the shield itself was found is shown in Plates 15 and 16. The eastern frames from Nos. VII. to XII. were all thrown back, but No. X. more than the others. No. XII. was stopped by the top floor-plate coming in contact with the east pier, and the pressure upon it was so great that the tail of the floor-plate was broken off just behind the side framings. From an inspection of Plate 15 it will be seen that in the other direction the frames had also been very much disturbed, more particularly those from No. VII. to No. XII., the whole of which had been carried laterally about a foot to the eastward at the upper part, leaving a space of seventeen inches open between the top staves of Nos. VI. and VII., through which the second irruption took place, and occasioning No. XII. to lean over upwards of two feet, although the frames at the time of the irruption were held together at the upper part by three powerful chains. But the principal violence of the irruption was exhibited at the east corner, where the ground had been disturbed and washed away down to the very foot of the shield, and the side bricking and staves (with the exception of the lower one) so completely dispersed that only two or three of them were ever met with, and those removed many feet from their original position; and this disturbance in the ground was not confined to that on the side of the shield, but also extended some distance behind the side of the east pier, leaving a cavity there extending almost from the top to the bottom of the Tunnel, as is shown in Figure 5, Plate 14, which represents the state in which the brickwork was found, the shaded portion at the upper corner showing the extent to which the three rings had been carried away at the crown, and at the invert the manner in which the brickwork had been worn or battered down to only half its former thickness, by the large gravel stones being urged against it by the water. Sir Isambart remarks, "If it is considered that that part of the structure, loaded as it has been since the water has been pumped away, had no abutment on the east side where the ground had been washed away; and that the arch itself was full of soil within three feet of the crown, it is hardly possible to conceive a more severe trial for the brickwork than that to which it has been exposed."[a]

The shield having been entirely cleared of the ground with which it had been filled, and its true state ascertained, it was determined not to attempt advancing with it until the whole of the frames should have been restored to their correct positions, and those parts of the shield which had been injured securely repaired. It is somewhat remarkable that on the afternoon of August 9th two of the frames (Nos. IX. and XI.) broke suddenly with a loud report like a shot, without being subjected at the time to any unusual pressure, and without any apparent cause whatever for so doing; the fracture of No. X. occurred first, and consisted in the complete separation of the west side of the lower box, the framing breaking off just under the bosses by which it was screwed to the floor-plates; and within an hour the second fracture in No. IX. took place, being also in the lower box, but upon the east side, and consisting of only the front rail, the framing being still held on by the back. In consequence of these fractures additional balks of timber were put behind the frames just under the lower floor, and securely strutted from the brickwork. The first proceeding in restoring the shield to a state of perfect security was to insert a new top stave between Nos. VI. and VII. in the space which had been caused by the separation of the eastern and western frames. A chase having been cut in the brickwork of the middle pier, to allow the tail of the stave to pass, and the ground having been trimmed to its proper level, (in doing which the bags were found uncommonly well condensed and united, the chisel rods having been productive of the best effect in pinning them together,) the stave was got into place after extreme difficulty, occasioned by the confined situation in which the men had to operate. This having been successfully accomplished, a similar operation was commenced at No. III., between which frame and No. II. a space of seventeen inches was left without any support, from the two extreme western frames having gone over at the top. The ground consisted principally of blue clay, but there being a small spot of gravel from which some water issued, it was thought necessary to secure it by inserting small boards above the staves of Nos. II. and III., which having been done, the new top stave was inserted in its place beneath them. The frame No. V. being the only one which was in its correct place, and perpendicular, the other frames on either side leaning away from it at the top, it was determined to commence with the adjustment of the shield at No. V., and to work from that frame each way to the two extremes. This was accordingly commenced by replacing the polings in No. VI., with others of greater length, to allow of their being more securely supported from No. V. on one side and No. VII. on the other; this having been done, and the top staves supported by shores from the top floor-plates of the same frames, the intermediate frame, No. VI., was then moved over bodily, and placed parallel with, and at the proper distance from, No. V. While these operations were being carried on in the shield, the ground above having time to consolidate, the influx of water was found sensibly to decrease, and at this period did not amount to more than 150 gallons at high water, and 100 at low.

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[a] Report of Sir I. Brunel to the Directors, dated Aug. 27th, 1827.

On the 20th, at the time of high water, another fracture took place, very similar to those which occurred upon the 9th; the backrail of No. IX. lower box (already broken in front) gave way with a tremendous crash, and in about ten minutes after the other side broke also. The report of the fracture was so sharp that most of the pumpers were alarmed by it, and ran away. The frames at this time, seriously fractured were—No. VIII., the west front rail; No. IX., east front rail and both back rails; No. X., both back and front rails on the west side,; and No. XII., the west front rail, both legs, the lower floor-plate, and a piece of the upper floor-plate. Of these fractures, with the exception of those in Nos. VIII. and XII., the whole had occurred since the irruption, and most extraordinarily, without being subjected at the time to any unusual strain or pressure.

August 22. No. VI., and also No. VII., having been successfully brought over; and placed in their proper positions, operations were next commenced upon No. VIII., which being one of the frames that had been thrown back against the brickwork, occasioned them considerable difficulty. In preparing to do this they discovered that both the legs were fractured, and also the bottom part of the front rail. It being likewise deemed prudent to lose no time in efficiently securing the ground on the east side, from which the whole of the side staves had been carried away, and which was in a very disturbed state; this was effected by first cautiously trimming the ground, and then placing against it three-inch planks securely supported from the side of No. XII. In doing this a hole was discovered in the side of the top box, about two feet six inches broad, full of hydrogen gas, which, on coming into contact with a candle, immediately ignited with a slight explosion.

On the 23rd, a little after the time of high water, another sudden fracture took place in the lower box of No. IX.; but what is the most extraordinary circumstance connected with this fracture is, that it did not proceed through the entire substance of the metal, and therefore could not have been produced by any strain upon the frame, but had more the appearance of a crack occasioned by sudden cooling, or an irregular contraction or expansion in the internal structure of the metal. On the following day, about the same time, a similar fracture occurred in the west back rail of No. XI.; in consequence of these repeated fractures in the frames, by which the five eastern ones had become quite disabled, face planks were placed against the polings, and being securely strutted from balks of timber placed at the back of the shield, and abutting against the brickwork, relieved the frames from a great portion of the front pressure. Notwithstanding this precaution, however, a few days after (on the 29th) three loud reports were heard to proceed from No. XI., and upon examination proved to result from as many fractures. They found that two more of the rails of the lower box had broke, (two being already gone,) which was thus completely separated from the floor-plate. On further examination they discovered that the other report had proceeded from No. X.; the lower cross-bracing, which received the abutment screw, (and which in the first shield was of cast iron,) was found broken in two pieces. The west rail of No. XII. in the middle box was also found broken. The lower boxes from Nos. VIII. to XII. were found to be so much damaged that it became necessary to remove them altogether and replace them with entirely new framings.

August 31. This was accordingly commenced by removing all the broken parts, the upper part of the frames being supported upon shores in the manner shown in Figure 6, Plate 14, which exhibits the condition in which the whole of the five easternmost frames were at this period.

On the eastern side of No. XII. the ground was found so much disturbed that it was determined to build up a solid brick wall to protect the ground, and upon which struts might be placed for the support of the frame, while the lower box was being removed. In order to obtain a substantial foundation for this wall, two rows of sheet piles were driven along the side beyond No. XII., upon the top of which strong planks were secured, and upon these was built a solid pier of brickwork in cement, the whole depth of the frame, and about three bricks thick. The replacing of the new framings in the lower boxes was also proceeded with, and on the 11th of September, Sir Isambart reported that "the broken parts of No. IX. have been removed and replaced by an entirely new set of castings for the lower boxes;—that the necessary shores and struts having been removed and transferred to No. X., the same operation has been successfully completed, and Nos. IX. and X. are now in every respect restored to their working condition. At No. XII. the preparations for supporting it while replacing the floor-plate have advanced as rapidly as the nature of them would allow, but it has been found necessary for the support of the ground sidewise, while moving No. XII., and also for carrying the frame while removing the lower part, to work a heading outside of No. XII. of considerable size, and to build a wall three feet thick of the whole depth and half the height of the frame. This, owing to the precaution required, and the necessity of cutting through some of the cast iron side staves which have been found buried in the ground, and also from the extent of the excavation and quantity of brickwork, has necessarily been a work of difficulty and great labour. It is now, however, finished, and the shoring from it will also be shortly completed. The head of No. VIII. has been replaced by a new one, the old one having been found partially damaged at our first entrance into the shield. The water is so inconsiderable as hardly to exceed what we had many months before the late accident." On the following day, however, at high water, the influx suddenly increased to such a degree that the pumpers could with difficulty keep it down.

In removing the fractured parts of the frames, in addition to the inconvenience of working in such a confined situation, a great deal of difficulty was experienced in removing the nuts from the bolts, many of which were so completely rusted together that it was necessary to cut them off; and a still greater delay resulted from many of the holes for the bolts in the new framings not exactly coinciding with those upon the old. Notwithstanding, however, these interruptions, Sir Isambart was enabled to report the completion of the eastern frames by the 18th.

"The shoring necessary for supporting No. XII. has been completed, the upper part of the frame being carried upon the contiguous frame, No. XI., and upon the side wall; the whole of the lower box of No. XII. and the bottom floor-plate, weighing nearly a ton, has been placed and bolted, an operation of considerable labour and difficulty in so confined a place, and under the heaviest pressure of the new-made ground. The shoes have been restored to their proper level, and the lower box of No. XII., half of which is new, is nearly completed; and the necessary preparations are going on for bringing that frame parallel with the contiguous one. In the west arch the frames are also in progress of being brought to their original situation, so that the opening existing between Nos. II. and III. will be closed. When these operations are completed, which will, I hope, be the case this week, the shield will be ready to move forward. The ground in front of No. IV. has been worked down this week; it presented everywhere a sound appearance. The top box of No. III. has also been worked down. For about three feet from the top, the bags of clay were found resting on a *thin stratum of sand*, which must have been in water for many weeks; loose, however, as it is in its nature, it has resisted the pressure of the new ground which it must have had to bear for upwards of three months."

Nos. I. and II. having been restored to their perpendicular position, and the side staves brought up close to the former, the space thus left behind them was filled in with brickwork.

September 28.
Weekly progress 1 6
Length completed 550 9

The whole shield having now been put into working order, progress was again recommenced on the 25th, after a delay of eighteen weeks. The first frame advanced was No. X., which being followed by the other frames on that side the east pier was brought up, and two rings of brickwork turned, making eighteen inches for the first week's progress.

In working down the lower face of No. IX., one of the side staves belonging to No. XII. was found embedded endwise in the ground, as though driven there from the interior of the frame. The ground in front of Nos. XI. and XII. was so extremely loose that the polings could not be removed to work the face down; the only expedient which could be resorted to for working those frames was to force the polings forward with a long jack, allowing the ground (which was a stinking black mud, quite fluid, having a small quantity of gravel mixed with it) to squeeze in at the sides and ends. The influx of water, which was principally from the side of No. XII., was found to increase somewhat in quantity since the resumption of the works, amounting to about 200 gallons per minute; this was probably occasioned by the movement of the frames loosening the ground and opening passages for the water to flow through.

On the 2nd of October a run of slate coloured lumpy clay, mixed with putrid river deposits, and a small portion of gravel, came in at the west top corner of No. I.; the influx had again decreased, and did not exceed 120 gallons per minute. The side stave of No. XII. was got out whole from the bottom box of No. IX., where it had given much trouble and occasioned considerable delay in working down the face.

October 5.
Weekly progress 2 6
Length completed 553 3

On the 5th, for two hours after high water, the influx was so considerable as to overpower the pumps, but it afterwards subsided, and did not permanently exceed its former amount. In consequence of the extremely loose state of the top face of No. XII., a boring was made into the ground ahead for the purpose of ascertaining to what distance the looseness extended; by this means it was discovered that the ground, for the first three feet, consisted of bags and loose gravel mixed, beyond which it consisted entirely of gravel. Having driven in an iron pipe, the boring was continued, but at about five feet six inches the bit was broken off at the joint by coming in contact with a piece of slag; after some little difficulty they succeeded in passing through this, and came into something smooth and tough like clay and silt, at a depth of about seven feet, when the bit having again broken, the boring was discontinued. A somewhat singular circumstance which attended this boring was that the boring pipe was found filled with an inflammable gas, which took fire and burnt at the mouth of the pipe upon the application of a light.

October 12.
Weekly progress 2 6
Length completed 555 9

On the 11th a considerable run of mud and slush took place at the top corner of No. I. which occasioned some difficulty in getting in the side bricking; and again upon the 17th about 2 A.M. another run occurred, which although not very serious in itself, created a considerable panic amongst the men, the following account of which is given by Mr. Brunel:—" Having seen all right below, I retired as usual to supper; just as I had taken off my coat and boots, Kemble came in rather a hurry, to tell me in a trembling voice that the water was in again; I would not believe him,—while hastily pulling on my boots I asked him how it happened,—how he knew it. 'It was up to the shaft when I came, Sir;'—this was decisive, I ran as fast as I could without my coat (giving a double knock at Mr. Gravatt's door in my way) to the shaft. All the men were on the top, looking for, and calling anxiously to those who, they said, had not had time to escape. Indeed, Miles had already, in his zeal for the safety of others, found a long rope, which swinging about, he called to the unfortunate beings to lay hold of, encouraging and cheering those who might be failing in their endeavours to swim or to obtain a landing. I ran, or rather threw myself, down the staircase; the shaft was dark, and I expected every moment to splash into the water. So quickly did I go, that before I was at all aware of it I found myself in the Tunnel. I met one or two running up. I soon reached the frames in the east arch, and saw Pamphillon, who told me that *nothing was the matter, but a small run* in No. I.; found Huggins and the 'corps d'élite' there, and a run of mud at the west top front corner, but nothing serious. One of the bricklayer's labourers hearing the man in No. I. call for assistance and straw, thrust in a whole truss of straw, and then, overcome with fear, jumped right off the stage, crying '*Run! Run! Murder! Put the lights out!*' and his fellow-labourers followed like sheep, repeating these extraordinary cries. Most of the men being at supper, and distant from the frames, the panic spread rapidly."

The amount to which the ground gradually and imperceptibly settled down in front of the shield was exemplified in a remarkable degree by the following circumstance; a piece of boring pipe which had been driven into the middle cell of No. IX. immediately after the frames were re-entered, was now found level with the lower floor-plate, about three feet below the place where it had been driven, and being still perfectly horizontal the whole face must have descended bodily to that extent.

October 19.
Weekly progress 3 0
Length completed 558 9

On the 18th, about the time of high water, there was a great deal of water from No. VI. at the middle of the top staves. The ground improved upon the whole, but there was a vein of muddy sand and diluted silt, about three polings thick, in the top faces, which extended from Nos. V. to XII. On the 20th a run of about three barrows full of gravel, with a small quantity of silt, took place in the middle of the lower face of No. XII.; and on the 23rd a very considerable cavity was discovered at the back of the top box of the same frame, into which a whole truss of straw and several brickbats were rammed, during which operation the ground, although gravel, stood well. The water was found to shift suddenly from place to place, and the ground to vary considerably in its nature in the interim of only a few hours.

October 26.
Weekly progress 3 4
Length completed 562 1

On the 29th another cavity was met with above the east top stave of No. XII., of so great an extent that the top stave could be freely rocked up and down; it was filled with clay and straw, pushed into it in the best way that could be done; but from the peculiar situation of the hole it was impossible to do it perfectly. The following was the general state of the ground:—" The ground in the top boxes is generally good, with the exception, however, of a stratum of silt of about one foot thick, and about the same distance from the top, the same that we have had for 100 or 120 feet back. It appears to lay immediately under the bed of clay, which we are just entering at the top. The precaution that is still necessary, however, is the cause of our progress not being more rapid. In the middle boxes the face consisting of shells and silty clay, the same as we have generally had, is compact and drier than formerly. In the bottom boxes the gravel in the face is exactly the same as formerly; generally hard, but having veins of loose shingle and fine sand, which run when exposed. The lower part of the face and the bottom forming the foundation are very good."[a]

On the 31st, although the tide rose to a most extraordinary height, (being in fact the same tide which overflowed the coffer-dam and filled the St. Katharine's Docks,) no unusual softness was found in the ground; nevertheless some fears were entertained of an irruption of the river, not through the ground but over the top of the shaft, the entrance to which it was found necessary to dam up with planks and clay, the water rising all round it.

November 2.
Weekly progress 4 0
Length completed 566 1

On the 3rd of November the ground was so soft that a pricker could be pushed two feet into the face without any difficulty. On the 5th a circumstance occurred which showed the varying nature of the ground, and how little dependence could be placed on any apparent improvement;

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[a] Report of Sir I. Brunel to the Directors, dated October 30, 1827.

for on that day, at low water, the top face of No. I., which for some time past had been so loose as to require much caution in working, was found so greatly improved that the miner very improperly took down six polings at once; and at high water, only a few hours afterwards, the same ground had become so loose and wet that it was not without much difficulty that the side bricking could be put in; and only three days after the whole face had become so soft that the top polings could not be taken out at all for working them down, and it was found necessary to screw them bodily forward with a long jack; the softness in the ground also extended to the back of the box, where it swelled in so quickly that the brickwork could not be got in until a vent had been given to the water by boring into the ground, by which operation it became concentrated to one spot, from which it ran in a clear stream, causing the surrounding ground to become much drier.

November 9.
Weekly progress 4 6
Length completed 570 7

On the evening of the 10th a very interesting occurrence took place in the Tunnel, Mr. Brunel giving a dinner in the western arch to several of his friends, to commemorate the expulsion of the Thames. The cross arches were hung with crimson drapery, and the tables were lighted with handsome candelabra of portable gas, and the band of the Coldstream guards being in attendance in their full uniform, produced a very striking scenic effect. The miners and bricklayers, to the number of more than a hundred, dined at the same time in the other arch.

November 16.
Weekly progress 5 0
Length completed 575 7

The slowness of the progress of the shield at this period is accounted for in the following report of Sir Isambart:—"It requires often four men to work one box, even when only one poling is taken down; two to remove the stuff, which they remove with their hands, and the two others to supply straw and clay. This accounts for the increase in expense, and decrease in progress, which although apparently inconsistent with each other, are in fact both the effects of the same cause. The progress of the whole is regulated by the worst part of the ground."[a]

On the 18th a run took place at the top corner of No. I., of a more serious nature than any which had occurred since the irruption, consisting of large lumps of blue and yellow clay, which came in with great force, and in considerable quantity. The ground being so loose, in order to put in the brickwork some iron pins were driven in over the staves to give an additional support to the ground; and at low water it was attempted, but the ground showed so great a disposition to run, that it was thought prudent to desist, and additional shores were placed for its support; but these not having been properly secured, presently came down, bringing the pins also, and followed by the ground, which fell in with considerable force, and although the men exerted themselves well, several barrows full came in before it could be secured. The brickwork was, however, put in without much difficulty the following low water.

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[a] Report of Sir I. Brunel to the Directors, dated November 13th, 1827.

November 23.
Weekly progress 3 0
Length completed 578 7

On the 21st the tide rose again to an unusual height, overflowing its banks and submerging some of the streets in the neighbourhood of the Tunnel to a depth of some feet; nevertheless no unusual effect was produced by it in the shield, the ground, if anything, being somewhat drier than ordinarily. The worst ground was in Nos. I. and II., where it was of the consistency of treacle, running through every crack or crevice, however small. On the 23rd about four barrows full came in at the latter frame; and on the following day, in working No. I. the treacherous nature of the ground was well exhibited; when the top poling was removed, the ground appeared much improved, and stood well, but in a few seconds it began to swell, and suddenly rushed in with so much violence that it was with great difficulty that the poling could be replaced; many of the lumps of broken clay which came in were four or five inches square, and they were accompanied by some river deposits. "We have in consequence [of the loose state of the ground] proceeded slowly, never working Nos. I. or II., except at low water. This sort of tide work prevents the frames being moved more than once in three tides, or thirty-seven hours. During this slow progress it is necessary that as soon as the frame where the difficulty exists is ready to be moved, all the other frames should be simultaneously carried forward, and the brickwork brought up with great expedition, and in fact more rapidly than usual, as otherwise the following low water would be lost; this accounts for the amount of labour being in these cases as great, and often greater, than the usual amount."[a]

November 30.
Weekly progress 5 2
Length completed 583 9

No. I. having gone over to the westward, leaving a considerable space between itself and No. II., it became necessary to move it bodily back to its proper position, and the side staves having been brought close up to the frame, the space left between the back of them and the side bricking was filled in with clay and straw.

December 7.
Weekly progress 6 2
Length completed 589 11

On the 6th of December a run of diluted clay took place at No. II., leaving a large cavity in the face, which required half a skip full of clay to fill it. In working down No. III., the ground was found so hard, (although only two hours before high water,) that the pick had to be used, a circumstance which had not occurred before since the irruption, but even here symptoms of moisture showed themselves before the second poling had been worked. On the 11th, upon removing the top poling in No. I., for the purpose of working down the face, a considerable cavity was discovered in the ground; the clay forming the roof of which supported itself, and was quite firm and dry. A decided change was perceptible in the ground at the upper part of the excavation; the strata of sand which had for some time previously existed at the two top polings, running into a plastic clay, and the ground at the third poling having become the worst. The extremely variable nature of the ground is remarkably shown by the following reports of the state of the ground in the upper face of No. I., for three consecutive days:—Dec. 12th, "Huggins, whilst observing the occasional increase of water at No. II., heard a splash in No. I., and on going there found the *commencement of a run* at the side; having called Bluett to his assistance, and applied straw and wedges, the attempt was prevented." On the following day Mr. Beamish reported, "saw No. I. go up the first fleet, and the top poling cut back; *the ground so good obliged to use a pick*, but as usual, before both polings were in the face became soft." And again, only the next day, "No. I. had gone up one fleet last shift, but owing to the rising tide, and the *strong disposition in the ground to run*, the top polings could not be cut back. Williams made two attempts, but the top polings followed as he unscrewed. Although not so much water generally, or in the west corner, a constant oozing of lumpy clay and sand took place at the side of No. I., through an opening so small as not to allow two fingers to enter."

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[a] Report of Sir I. Brunel to the Directors, dated Nov. 27th, 1827.

December 14.
Weekly progress 5 10
Length completed 595 9

"Our progress this week has been rather slow, having advanced only five feet ten inches. The ground generally, except at Nos. I., II., and III. top, has rather improved. At those points it continues much the same, as the state of this part has caused considerable delay, particularly this week, although not such as to give any cause of anxiety as to our future rate of progress, or to have any serious effect, except the increased expense incidental to this delay. There is (as stated in a former report) a considerable *spring* at this point, and a corresponding soft part in the bed of the river, which seems to indicate the rising of the spring. The ground in the neighbourhood is affected by this spring in rather a peculiar manner; at the *half flood* tide the pressure is *greatest;* dry hard clay oozes with great force through openings hardly observable, the silt and water running by starts. At *high water* the pressure and quantity of water *begin to diminish*, and on the *ebb tide* the ground is *hard* and *dry*, and can *be worked with ease.* On the flood tide there are continually as many as twelve and fifteen of the best hands, besides myself (or one of my assistants) and the foreman, engaged entirely at one face. This includes six cool steady men, who must also be tall and strong, two in front of each box; others cutting small struts, wedges, &c., to the exact size called for, making up bundles of straw and fascines of different sizes, and lumps of clay, and others handing in what is called for, and poling screws of all lengths, and any tools required. I have entered into these details to account for the number of men employed, and which, as I have often stated, sometimes increases as our progress decreases. During this time the men alluded to are working excessively under great excitement, drenched completely with spring water, and frequently blinded with the mud. Many of them are obliged to go upon the stage, put on dry things, and take drink to enable them to resume their work. I mention this to account for the clothes and drink which I have stated it was necessary to give them."[a]

On the 15th the east back rail of the top box of No. I. broke suddenly, with a loud report like that of a pistol. The ground was found extremely bad in No. I., where, notwithstanding the tide was running down, a quantity of lumpy clay made its way in at the top front corner, with considerable force. The run continuing, Mr. Brunel had the face timbered, so as apparently to stop every crevice, still some blue and yellow clay found its way in. On the following day Mr. Beamish reports, "The ground appeared to be too much in motion to allow of any of the timber being removed to get forward the frames; as the tide rose, the running again commenced, and at length, after using every exertion to prevent the clay actually forcing itself between the polings, and between the top poling and the top staves, Mr. Brunel found it necessary to board up the front of the box, filling in with clay and straw, so as to cut the box off; the ground also made its way between Nos. I. and II., large lumps of dark blue clay, and brown, followed the yellow, but as yet no gravel." Soundings being taken at low water, a hole was found over Nos. I. and II., running in the direction of the Tunnel, which in the most depressed part was six feet below the general level of the bed of the river. In consequence of this, two or three barge loads of gravel and clay were thrown over the spot. At low water on the 17th, the top face of No. I. was opened, and they succeeded in working it down without much difficulty; the gravel had come down and extended across the entire face at the top poling, and all beneath was clay. This extreme softness in the ground was not confined to No. I., but extended as far as No. V., from the back of which frame a considerable run of sand took place; and from No. II. a kind of slush, (consisting of clay broken up and mixed with water,) continued running in during the whole of the night, until at length the gravel came down, and then the water ran quite clear, and remarkably cold. On the 19th a rather serious run occurred in the upper face of No. III., when between three and four barrows full of the same broken clay made their way in. On the 21st the soundings again showed a depression of two feet over No. I., and the ground was found extremely soft all round, in consequence of which, about seventy tons of clay and gravel were thrown over.

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[a] Report of Mr. Brunel to the Directors, dated 18th December, 1827.

December 21.		
Weekly progress	3	0
Length completed	598	9

January 4.		
Weekly progress	3	0
Length completed	601	9

On the 22nd another run of such an alarming character took place at No. I., that the frame was again blocked up with planks and clay. Being Christmas week, the work in the frames was almost entirely suspended, and the few men who were in, were principally occupied in repairing the shield. The ground in the western frames, and No. I. in particular, continued of the same dangerous nature, there being an incessant running of slush and muddy water from every opening or crevice between the polings and the staves, however small. On the 3rd of January a very violent burst of water took place at the third poling of No. II.; it came in so suddenly, that many of the men were alarmed, and ran away. These sudden bursts of water, which, from its temperature and the violence with which it came, evidently proceeded from the river, prove that at this period the whole body of ground above the shield was broken up and disturbed to such a degree as to afford very little protection to the works. Although it consisted almost entirely of clay, which in a sound and condensed state would have formed the best and most secure covering which could have been obtained, in its then condition it was far otherwise; for having been first completely broken up into small lumps by the irruption, which were then exposed to the direct action of the water, for some weeks they became partially dissolved, and their exterior covered with a kind of greasy slime, which completely prevented them from ever becoming again united into one mass. Through ground such as this it may readily be conceived that the water had very little difficulty in making its way, and having once obtained a passage, as was the case at this time at No. I., the longer it continued to run, the more the clay became dissolved and broken up by its action; and although at intervals, from a little gravel or a less disturbed mass of clay intervening, a momentary improvement was found in the ground, the slightest disturbance, even the working down of the face, was sufficient to attract the water to the spot, which soon rendered the ground as bad as before. In this critical situation Sir Isambart felt that the entire safety of the works consisted in keeping in good order the covering over the shield, and in immediately filling up with gravel any depressions or soft places which might be caused in the bed of the river, by the continual runs of ground which took place in the frames. For this purpose soundings were carefully taken every tide, and gravel thrown over the depressed parts; but still the information obtained in this manner was very imperfect, and little could be ascertained of the real state of the bed, without an inspection with the diving-bell. Sir Isambart, therefore, applied to the West India Dock Company for the loan of the one which they had had before, but unfortunately this could not be obtained, as it was being used in some repairs to the docks. Under these circumstances nothing remained but to advance with extreme caution until the shield could be brought into the undisturbed ground.

On the 8th, the Tunnel was visited by Don Miguel, when Sir Isambart accompanied him to the frames, and explained to him the mode of proceeding; after partaking of some refreshment, and having drank to the success of the Tunnel, his royal highness withdrew, to the very great relief of Sir Isambart, who felt very uneasy lest any irruption of loose ground should take place, and create a panic amongst the visitors, of whom above a thousand in number were present upon the occasion. On the 9th, a very considerable stream of water burst out from the top of No. II., and from the quantity of mud mixed with it, indicated some new derangement in the ground; and on the following day, when the top poling was removed for the purpose of working down the face, a cavity was discovered in the ground, extending about two feet forward, which was filled in with straw and clay.

January 11.
Weekly progress 3 6
Length completed 605 3

Nothing of any importance occurred between this and the 12th, on which day, about six A.M., the river suddenly broke into the shield at No. I., and quickly filled the Tunnel, when it is extremely melancholy to have to record that six men were drowned, and Mr. Brunel himself had a very narrow escape with his life: the following is Mr. Brunel's report of the occurrence:—

"I had been in the frames with the workmen throughout the whole night, having taken my station there at two o'clock. During the workings through the night, no symptoms of insecurity appeared. At six o'clock this morning, (the usual time for shifting the men,) a fresh set or shift of the men came on to work. We began to work the ground at the west top corner of the frame (No. I.); the tide had just then began to flow, and finding the ground tolerably quiet, we proceeded by beginning at the top, and had worked about a foot downwards, when on exposing the next six inches the ground swelled suddenly, and a large quantity burst through the opening thus made. This was followed instantly by a large body of water. The rush was so violent as to force the man on the spot where the burst took place out of the frame on to the timber stage behind the frames. I was in the frame with the man, but upon the rush of water I went into the next box (or cell), in order to command a better view of the irruption, and seeing that there was no possibility of then opposing the water, I ordered all the men in the frames to retire. All were retiring, except the three men who were with me, and they retreated with me. I did not leave the stage until those three were down the ladder of the frames, when they and I proceeded about twenty feet along the west arch of the Tunnel. At this moment the agitation of the air by the rush of water was such as to extinguish all the lights, and the water had gained the height of our waists. I was at that moment giving directions to the three men in what manner they ought to proceed in the dark to effect their escape, when they and I were knocked down, and covered with a part of the timber stage. I struggled under water for some time, and at length extricated myself from the stage, and by swimming and being forced by the water, I gained the eastern arch, where I got a better footing, and was enabled, by laying hold of the railway rope, to pause a little, in the hope of encouraging the men who had been knocked down at the same time with myself. This I endeavoured to do by calling to them. Before I reached the shaft, the water had risen so rapidly that I was out of my depth, and therefore swam to the visitors' stairs; the stairs for the workmen being occupied by those who had so far escaped. My knee was so injured by the timber stage, that I could scarcely swim or get up the stairs, but the rush of the water carried me up the shaft. The three men who had been knocked down with me were unable to extricate themselves, and I am grieved to say they are lost; and I believe also two old men and one young man in other parts of the work."

Of the proceedings subsequent to the irruption, we cannot do better than give the following detailed account, contained in a report of Sir Isambart to the Directors, dated the 22nd of January, 1828:—

"On the morning of the accident, in consequence of the intensity of the fog, no observation could be made, nor could any soundings be taken. The diving-bell was sent for, and as soon as it could be removed from the West India Docks, was towed to Rotherhithe.

"It could not, however, be used at the night tide. On Sunday, the 13th, Mr. Gravatt descended first, but the chain (which is fit only for the service of the West India Docks) was found too short for our situation; nothing could be done during the very short time of slack water but sounding, which is very unsatisfactory even at best; this was a very great disappointment, as the west side of the shield was still open, that is, free from the ground which the current has subsequently washed in. In the mean time all hands were employed on shore, and in the barges, in tempering clay and filling bags. It being Sunday, a proper chain could not be procured; a rope was accordingly tried for the diving-bell, but it broke; having succeeded in procuring a chain of sufficient length, Mr. Gravatt went down on the 14th, in the morning, and reported that the brickwork appeared to be sound and undisturbed. The frame No. I. in place, and the top staves level; but at No. II. two of the top staves appeared to be deranged.

"I was preparing to go down, but the air pipe which had been lengthened from an ordinary hose not proving air tight, I was obliged to come up again before I could reach the bottom. The weather was all the time most tempestuous, cold, and rainy, the tides very violent both up and down, and our barges were exposed to be fouled at every instant by the craft and shipping. At seven P.M. I went down, Mr. Gravatt being with me, but our sextant having fallen overboard, we were not very sure of our position, and the signals not being well understood above, we were carried against the west side of the cavity, and exposed to the danger of being upset: we were obliged again to come up.

"Tuesday, the 15th. At half-past six A.M., having procured a sextant, we found that we had been driven off near twenty feet, but having removed our position, I was able to stay under water as long as the chain would enable us so to do. I found No. I. covered with about two feet six inches to three feet of ground, which the tide had washed down upon it. I was not able to ascertain with sufficient degree of accuracy the state of No. II., where Mr. Gravatt had made his observations before. He had, however, brought up a brick, a wedge, and a rope, which must have come from No. I., from the side brickwork. The ground rises on the east, which indicates that the frames on that side have not been disturbed.

"Wednesday, the 16th. I went down again, and remained upwards of two hours and a quarter, having then about forty-two feet of water, but could obtain no additional information; I therefore ordered the men to throw two barge loads of bags of clay, and after they had been thrown in the way we had done before, I descended to examine how they laid. Finding them as well as could be expected from the state of the tide, I ordered, on the 17th, to proceed in throwing large bundles of bags through an opening made in the raft. All hands were employed in tempering clay, filling the bags, and throwing them in, when the tide was low enough; I thus proceeded as we had done before. On the 18th, continued the operation of filling bags of clay, and when the tide was low, I availed myself of that time to have soundings taken, which indicated that the bags were taking their right direction.

"Saturday, the 19th. Having thrown a sufficient number of large bundles of bags, I ordered to throw small bags with iron rods, instead of hazel rods, over No. II. During Sunday continued throwing bags of clay and gravel.

"Monday, the 21st. All hands employed as before, some on shore to prepare clay bags, others afloat. The pumps being tried, for the purpose of ascertaining whether they had been disturbed by the sudden irruption of the water, were found in good order.

"I have thus reported the proceedings I have adopted since the accident, and the means used for securing the works; but the boisterous weather, the velocity of unusually high tides, the shortness of the days, the insufficiency of the diving-bell apparatus for our purpose, and the absence of my son, have prevented my investigations being as satisfactory as they were immediately after the last accident, which occurred at the most favourable period of the year for out-doors' work and on the river.

"I think it, however, proper to add, that from my inspection of the ground over the shield, and from the report made to me from one of my assistants, which I have before referred to, there does not appear to me any reason to doubt but that the means which I had formerly adopted for remedying the first accident may be successfully applied to remedy the present; and with the experience of the first, I trust at less expense."

Although the bed of the river over the cavity had been raised above the natural level of the surrounding part, the throwing over of bags of clay and gravel was continued, since the new-made ground was found to sink very much, first over No. I., and then at Nos. VII. and VIII. The filling having been inspected with the diving-bell, and being found sound, and the bags laying well, the pumping was commenced and a head of from sixteen to twenty feet obtained; but "on the 1st instant [February], the ground settled down very considerably over Nos. XI. and XII., just as was the case with the preceding accident. The water rose in consequence of it four feet in an hour, and from that moment the water has flowed in and out without any sensible difference till last night [the 4th], when a head of nine feet was again obtained. The heap of ground raised over the excavation was a few days since not less than from twelve to fourteen feet high above the natural bed of the river. I found it yesterday reduced to about nine feet. The last filling, which at one time exceeded eight feet, is now quite level with the bed of the river."[a] The pumping being continued, the water in the shaft was kept at a lower level than that in the river, in order to condense the ground, and add to the consistency of the

[a] Report of Sir I. Brunel to the Directors, dated Feb. 5th, 1828.

covering; and on the 9th, a head of twenty-seven feet was obtained, but in the course of the evening it became reduced to seventeen. "The rate of the increase and decrease of the water in the shaft has been extremely irregular, sometimes rising and falling with the tide in the river four feet in an hour, and sometimes not more than five inches in the same time. These irregularities indicate that the natural ground is settling under the new ground, or that the new ground is making its way into the shield, both which movements are to be expected, and to be wished. The soundings have not shown any considerable partial depression in the bags, or filling, but the mass has settled a good deal; we have still a mound of between seven and eight feet above the natural bed of the river."[a] As yet the covering had not acquired sufficient consistency to allow of any considerable difference in the levels of the water in the shaft and the river being maintained for any length of time. For although the water had several times been lowered in the shaft many feet below the river, it had as often risen again to the same level within a few tides, clearly indicating that the ground was still in movement, and that the mass of bags of which the covering was principally composed was not sufficiently condensed to prevent the water from finding a passage through it. In order to check this, and fill up any interstices or cavities that might exist amongst the bags, Sir Isambart ordered a larger proportion of gravel to be thrown over than had been previously done. This was found to have a beneficial effect, for Sir Isambart reported,—"Since the 23rd of February, the head of water on the river side has been gradually increased, and regularly maintained. To day [4th of March] the head of water is twenty-four feet three inches, with the steam engine going at a very low rate only, a proof that the infiltration is much less than what the steam-engine could take up, if it were expedient to remove the water faster than is done. I think it necessary to proceed with the same precaution, in order that the ground may acquire still more consistency."[b] By proceeding in this manner, and removing the water very gradually, a head of forty-three feet was obtained by the 20th, the water being sufficiently reduced to allow the men to repair one of the pumps which had been damaged, and to repack the others. And on the same day Mr. Beamish proceeded in a boat about two hundred feet down the east arch, but was prevented from going further by the great quantity of floating timber. "I regret to say, however, that on Friday morning [the 21st], the water rose again, and filled the shaft. At the rate it rose, (just above the soffit of the arch, where it can be easily measured,) it would have taken four or five hours to have filled the Tunnel. The waterways, therefore, cannot be very considerable. Having no diving-bell at our disposal, the ground had not been examined since the bell was recalled on the 8th instant, and after the settlement which has occurred we have no knowledge of the state of the ground, except with the sounding rod, which is of course a very imperfect instrument under such circumstances. A depression was discovered at the front of the shield, towards the east side. I immediately ordered some good gravel to be thrown in; on Saturday there was a sensible effect already produced; on Sunday a head of eight feet was obtained; yesterday morning it was eight feet four inches, and eleven feet eight inches in the afternoon; this morning it is eight feet four inches. We cannot go on with any satisfactory result without a diving-bell always at hand, with a suitable appendage, particularly when we advance farther into the river."[a]

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[a] Report of Sir I. Brunel to the Directors, dated Feb. 12th, 1828.

[b] Ibid, dated Mar. 4th, 1828.

The pumping being continued, the water lowered gradually and very regularly, and by the 6th of April was once more entirely out of the shaft, and the men were set to work in clearing the arches of the floating timber. On the 8th, the soundings showed a depression of two feet over the tails of Nos. II., III., and IV., in consequence of which extreme caution was enjoined, and orders were given to employ as few men as possible in the clearing of the arches. On the 11th, Mr. Beamish proceeded in a boat down the west arch, but found it impossible to get into the shield upon that side, from the arch being completely filled with ground for several feet back. On the following day, however, Mr. Gravatt succeeded in once more re-entering the shield from the east arch; he found the frames nearly clear from Nos. V. to XII., and a very strong stream of water from the tail of No. VI. Shortly after, however, his return from the frames, the influx of water increased rapidly, and soon completely overpowered the pumps, coming in at the rate of from 1,500 to 2,000 gallons per minute; and continuing to rise steadily by the following morning the shaft was once more filled. Soundings being immediately taken, a considerable settlement was discovered to have taken place in front of the frames, in consequence of which several barge loads of bags and gravel were thrown over the spot, and on the 14th the pumping was again resumed. The soundings showed a continual settlement in the covering, and on the 19th, a depression was found about fifteen feet ahead of the frames, about two feet deep, and extending from Nos. VI. to XII. By the 27th, the water was again reduced sufficiently low to enable them once more to reach the shield, and the following is an account of the state in which things were found. "The west arch has been found as I expected it, filled as the east arch was at the first visit. The frames Nos. I., II., III., and IV. have been found forced back at the top, as the frames Nos. VIII., IX., X., XI., and XII. were after the first irruption; a portion of one ring of brickwork is displaced; and the centering has receded nearly in the same proportion. The frames were exposed to view from Nos. I. to XII., where the side bricking is in place. The top staves of Nos. I., II., III., and IV. are very much disturbed, not a single poling is to be seen, but the bags of clay are stretched as it were by the medium of the rods across No. I.; the fronts of Nos. II., III., and IV. are closed with bags, arching against and resisting the incumbent pressure. On the west side of No. I. a considerable cavity has been observed, not unlike that which presented itself at No. XII., after the first irruption of 1827; the bags will, it must be expected, close this cavity; the new-made ground is observed to be settling and closing in all directions round us, as was the case after the preceding irruption, and for upwards of four months afterwards, while the work was carried on under the protection of the bags."[a] In the last settlement upon the 12th, a considerable quantity of ground appears to have come in, and so choked up the east arch as to oblige the water to pass through the west, and wash the top frames on that side clear, as it will be recollected that at the former visit the west arch was found blocked up with ground to the very crown of the arch, so as completely to exclude all view of the shield.

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[a] Report of Sir I. Brunel to the Directors, dated March 25th, 1828.

In another report of Sir Isambart to the Directors, on the 6th of May, he says, "I visited the shield yesterday, and to-day again; the frames Nos. I. to IV. are, as I reported them last week, thrown back; No. V. is in the same state, but all the others stand as they were when left. The head of No. I. is displaced and damaged, two of the top staves still remain, all the top boxes are quite filled with bags, which act everywhere as poling boards; the backs of the boxes have been closed with strong planking. I beg to observe that the cavity at the west of the shield was not less than ten feet in length, about four feet in height, and in some places perhaps three feet in breadth; the circumstance of such an opening having remained so many days, probably weeks, open under a constantly varying pressure, which twice a day is not less than two tons on the square foot, is not only the strongest confirmation of the protection afforded by the bags, but the confidence is such in our minds, that none of us, nor any of the miners, feel any hesitation at working under it, notwithstanding the abundant showers of water, the casual bursts of gravel and slush, and the frequent loud reports proceeding from pieces of casting breaking."

The clearing of the Tunnel and shield from the ground which had been brought in at the irruption was now rapidly proceeded with, especially the clearance of the latter, which Sir Isambart was desirous of placing in a state of perfect security with as little loss of time as possible. In doing this ample evidence was afforded of the extreme violence of the irruption at the west corner; the whole of the polings from the top and middle, and even many of the lower faces, were entirely gone upon that side, and the side staves at No. I. were completely dispersed in the same manner that those of No. XII. had been at the previous irruption, one of them being found lying right across the lower face of No. IX., and the tail of another *underneath the shoes* of No. VII. As the clearance of the shield proceeded, balks of timber were inserted at the back of the frames, and securely strutted from the brickwork, in order to support them against the enormous strain to which they were subjected by the irregular settlement of the new-made ground, and by which, after the former irruption, notwithstanding the precautions then taken, the whole of the eastern frames in the lower boxes were successively fractured to such an extent, that it had been found requisite to replace them with entirely new castings. By the exercise, however, of great precaution, and by conducting the operation of clearing *quickly*, so that the ground had not time to settle to any very considerable amount, they succeeded in effecting it upon this occasion, and in securing the shield, and replacing the poling boards in all the boxes, with but one or two fractures, and those not of any considerable importance.

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[a] Report of Sir I. Brunel to the Directors, dated April 28th, 1828.

The funds of the Company being now nearly exhausted, the Directors had for some time past had under consideration the necessity of suspending the works for a time, and had applied to Sir Isambart, (even prior to the second irruption,) to report upon the best means of securing the shield, and that portion of the work which had already been accomplished, in such a manner that the works might not receive any detriment from the stoppage, and might without much difficulty be resumed at any subsequent time. The following is Sir Isambart's report upon this subject:—"In consideration of the first resolution, I beg to remark, that in the event of a suspension of the works being expedient, that there are in my opinion but two courses to follow. The first is by allowing the water to rise in the Tunnel again, and the second is to secure the face of the Tunnel, employing the engine to pump out the water of infiltration. With regard to the first plan, I consider it as a last resource, were the undertaking to be abandoned. The requisite preparations would be expensive, and the derangement of the work surrounding the shield would be so great, from the unequal action of the tides and the land springs, as to lead to an injury almost irretrievable, except at an enormous expense. With regard to the second plan, that of securing the face of the excavation, and employing the engine to pump out the water of infiltration, this is the only advisable plan of preserving the Tunnel with any certainty, both as regards the works during that suspension, and the resumption of the excavation."[a] The expense incurred by the second irruption, in the repair of the hole in the bed of the river, and in recovering and securing the shield, having still further exhausted the Company's funds, the Directors came to a resolution on the 8th of July, "That the works be closed, and the establishment and expenditure be reduced to the smallest number and amount possible, consonant with the ultimate security of the works." In accordance with this resolution of the Board, Sir Isambart determined upon adopting the second plan alluded to above; and in his next report to the Directors, says, "The way I propose, and which I have already given directions to effect, is to proceed as expeditiously as possible in blocking up the frames with brickwork set in Roman cement, not in a solid mass, but in strong piers; and as soon as this is done, to build an abutting wall against the whole, thus closing the end in so substantial a manner as to dispense with the expense of attendance, and remove at the same time all apprehensions for the future."[b] The blocking up of the shield in the manner above described was accordingly commenced and proceeded with, the lower boxes being the first secured; and as soon as this had been effected, the abutment wall or arched dome for completely closing the end of each archway, and for forming an abutment for the shield, and preventing any disturbance in the frames, was commenced, chases or footings being cut in the old brickwork of the Tunnel, in order to afford a secure abutment for it to spring from. In building this closing wall several cast iron pipes were inserted, some of them extending through the boxes completely into the faces, for the purpose of affording a free passage for the water during its construction. On the 29th of July, Sir Isambart reported that "the blocking up, that is, the closing wall, is proceeding with; I have, however, left nine of the upper boxes open, in order that I may see the effect of the ground over the shield to the last. It is, indeed, much to be regretted that the shield must be entirely blocked up, for in the state in which it is now, I consider that it is in the most advantageous condition for removing the top staves, and substituting others, or for any operation that might be wanted for its future progress." The blocking up of the middle frames having been completed, and the closing wall carried up to the level of the top floor plates, the upper boxes were next proceeded with, the faces being blocked up with brickwork, and the top staves carefully pinned, and in fact every thing rendered as secure as possible preparatory to finally closing up the arches; these objects having been all properly effected, the closing wall was proceeded with, and on the 15th of August, 1828, was completed.

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[a] Report of Sir Isambart to the Directors, dated Nov. 18th, 1827.

[b] Ibid., dated July 15th, 1828.

In a report of Sir Isambart to the Directors dated the 23rd of September, he states, "that in blocking up the arches of the Tunnel, in the peculiar and substantial way in which that operation has been done, every provision has been made for facilitating the resumption of the works, whether it be by continuing the present arches, or by operating from the opposite shore, and meeting the arches at the present end.

"The ground which covers the shield has been carefully examined, before the top cells of the shield were closed; most particularly at the west corner, where the irruption had caused the greatest injury; it was found to have acquired such a degree of density that the top staves might have been removed, and others substituted with much greater facility than was the case after the first irruption of the river.

"The gound forming the bottom of the river over the shield has been sounded, and has not been found to have altered much for several weeks past. I, therefore, now consider that it constitutes a substantial and complete protection against the river.

"Having complied with the instructions from the Court, and having placed everything in a proper state of security, I shall of course wait for more favourable circumstances; in the mean time, however, I am continuing to prepare for the future, when the Court will find me in readiness (whenever the time may come) for resuming the operations.

"Notwithstanding our disasters, the protection afforded by the shield cannot be questioned; nothing has yet been suggested that could have improved our present situation, or our means of opposing the ground. If we consider that the area of the present excavation, to which the shield affords protection, is forty-five times larger than that of the drift attempted in 1805, under the personal direction of men selected for skill, ingenuity and experience in the art of mining; and further, that when the river had once made its way into the drift, all exertions to secure it again were quite fruitless; or if we compare the fate of other enterprises which have been completely destroyed under circumstances far less perilous, much may indeed be expected, particularly under the additional protection afforded by the improvements which experience has dictated, from a plan that has already enabled us to do so much as has already been done, and to regain possession of the works, through such dangers and difficulties as those we have experienced.

"With respect to the structure as far as it is finished, its stability has been well tried, it has been constructed according to the original plan throughout; the mode of laying the foundations,—that of building in rings from three to nine inches,—and the use of Roman cement of the best quality, have concurred to constitute six hundred feet of a structure, which, even in a green state, has resisted the most violent convulsions which any structure has most probably ever experienced from the element under which we have had to operate."

In concluding this section we shall give the following letter[a] of Sir Isambart to the Directors, in acknowledgment of their resolution to suspend altogether the further progress of the works.

"I beg to acknowledge your letter of the 8th instant, informing me, that in consequence of the state of the finances of the Company, you are obliged to suspend the prosecution of the works of the Tunnel, and to reduce the establishment to the very lowest rate of expense, and requesting at the same time my ideas upon this point. I feel, in the first place, obliged by the manner in which the communication is made, as it cannot be otherwise than equally painful to me to see a discontinuance of the undertaking.

"I have, however, considered for some time this suspension as inevitable, and have accordingly directed my attention to the least superintendence necessary for the preservation of the works in their present unfinished condition.

"The operations have hitherto been conducted under me by a resident engineer and two assistants. The two gentlemen who filled the latter situations, Mr. Beamish and Mr. Gravatt, have already been informed that their services are no longer required. The men will gradually be reduced to the few who must remain in charge of the works, so as to preserve the Tunnel in its present state, which is the most desirable with a view to its completion.

"With regard to my own engagement, I beg distinctly to state (though the future operations of the Tunnel will necessarily occupy much of my time and attention, if it be only in digesting plans for its continuation), that in the present state of the finances of the Company I feel it my duty to give up the salary attached to my office, whilst I shall be equally ready to discharge every duty that may be required of me. As, however, other vocations will occupy a large portion of my time, and sometimes perhaps at a distance, I propose to leave the works in charge of my son, who will continue to reside on the spot, and direct every necessary measure for their preservation.

"I may be permitted to add, that I consider the Tunnel as safe and durable as it can be rendered in an unfinished state; that I consider the resumption and continuation of the works from the present end, perfectly practicable, and that in the mode I have adopted to close it I have provided to that effect.

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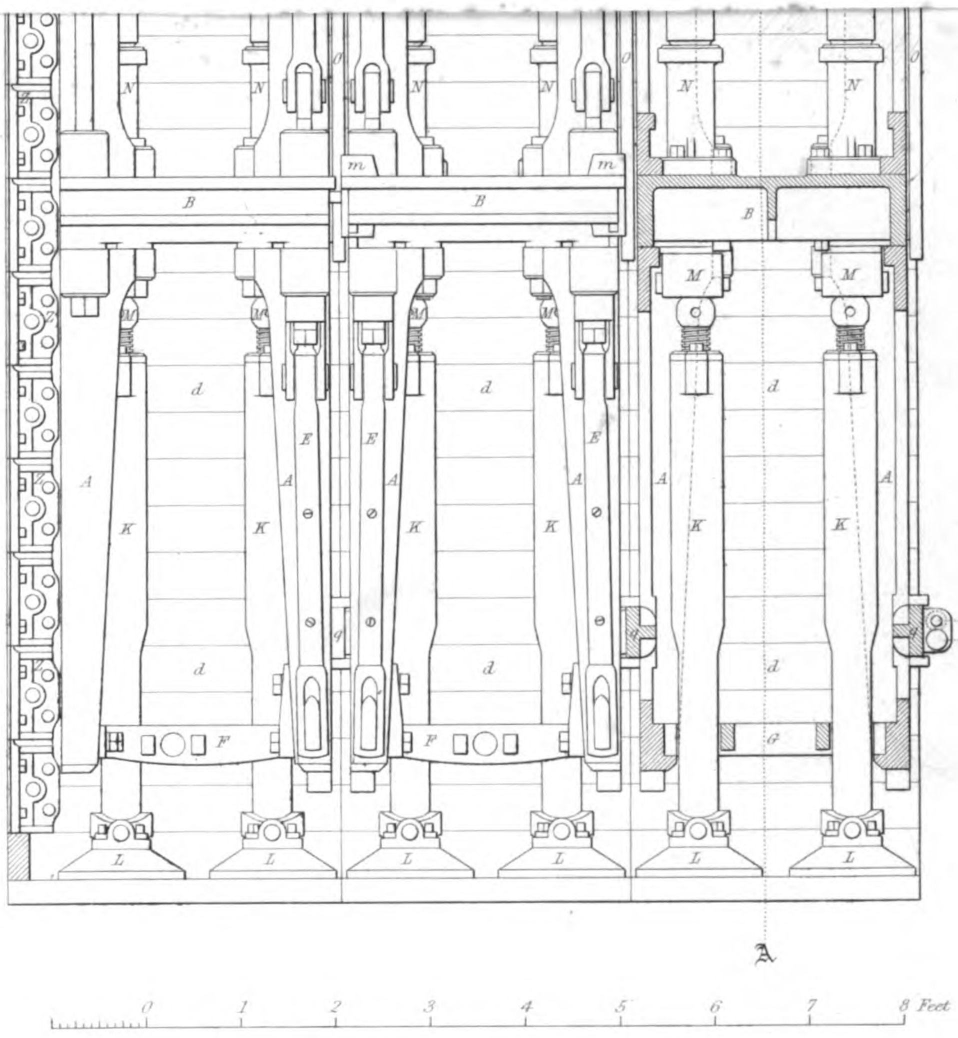
[a] Dated the 19th of August, 1828.

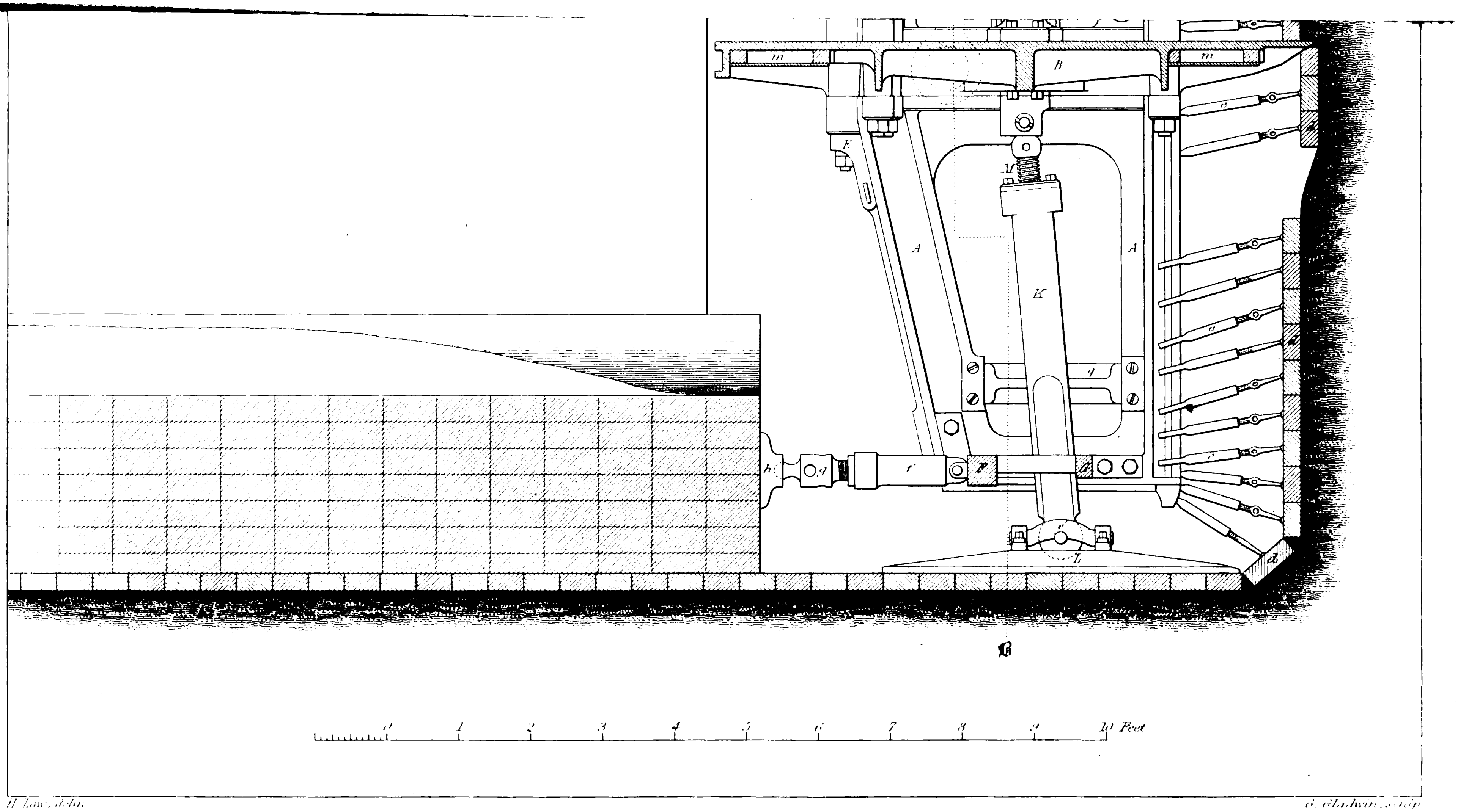
" I accordingly lament the unforeseen expenses we have incurred, but I must assure the Court that *nothing but the want of funds can now prevent the completion of the undertaking.*"

We can hardly help participating in Sir Isambart's feelings upon this occasion; when, having successfully accomplished half the Tunnel, and demonstrated (beyond a shadow of doubt) the capability of the shield, and the sufficiency of his plan, to accomplish the remainder in spite of all obstacles which might present themselves, (having already twice successfully surmounted the greatest accident which could happen to the work,) the undertaking was now to be abandoned solely and only from the want of money; its ultimate completion rendered extremely problematical, and even the possibility of effecting it left a matter for speculation; at the same time giving a temporary triumph to those who, from want of sufficient information, or from a perverse and interested scepticism, had always predicted the failure of his plan, and enlarged upon its insufficiency and absurdness *when compared with their own.*



H. Law, delin. G. Gladwin sc.

London, John Weale, 1845.



H. Law, delin.

G. Gladwin, sculp.

London, John Weale, 1845.

THAMES TUNNEL

Details of the Shield.

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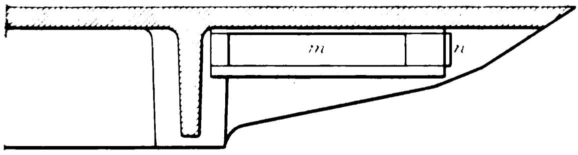
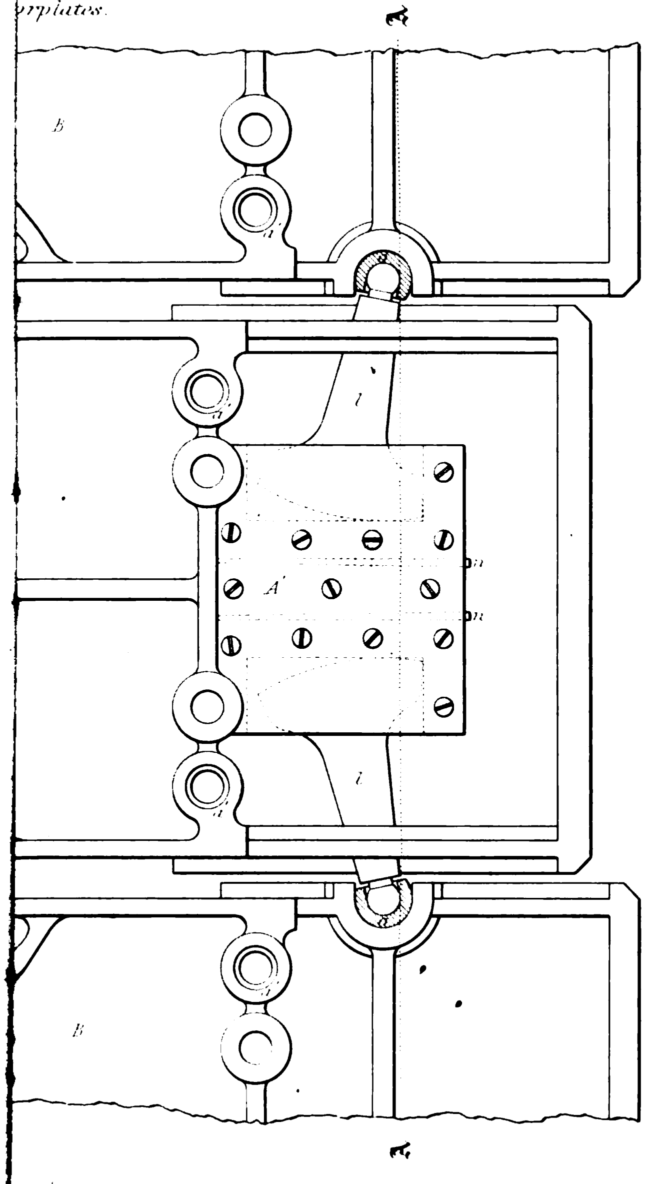


orplates.



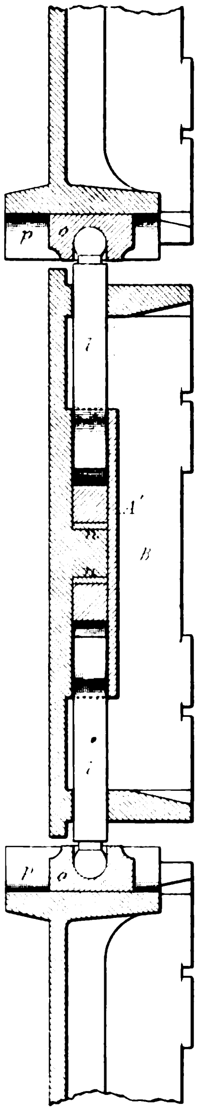
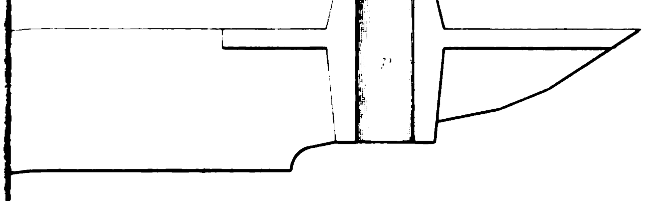
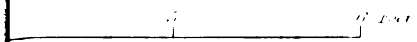


Fig. 6

Transverse Section of the Lower Floorplates, on the line A.A.

of No II.





G. Gladwin sc.

Fig 2

Section on the Line B,B.

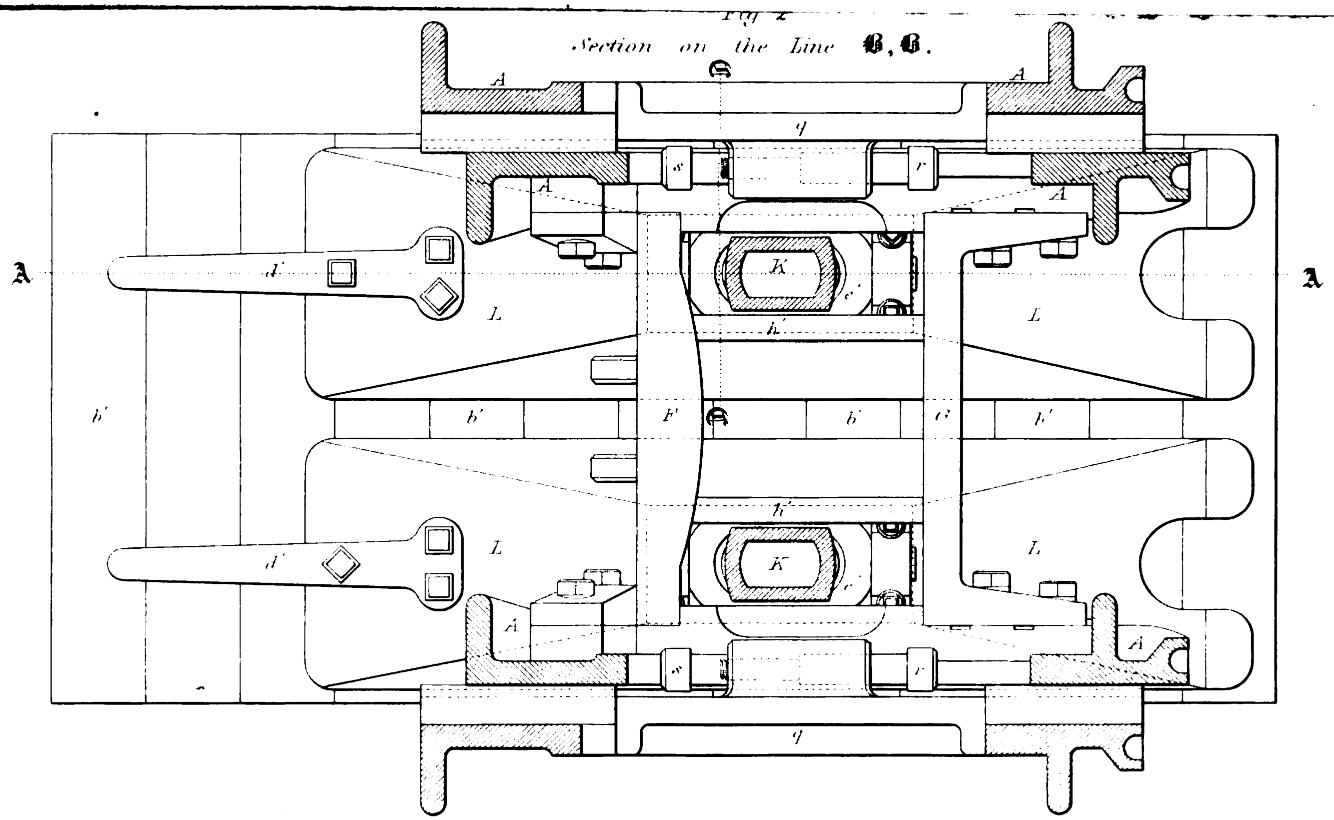
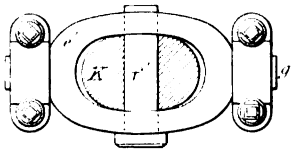


Fig. 4

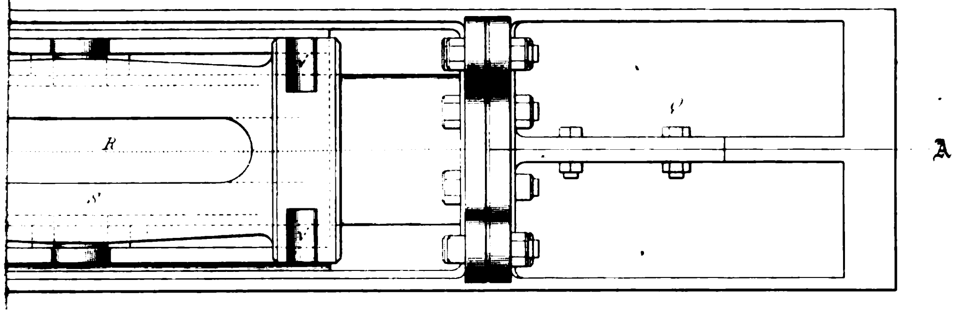


H. Law, delin.

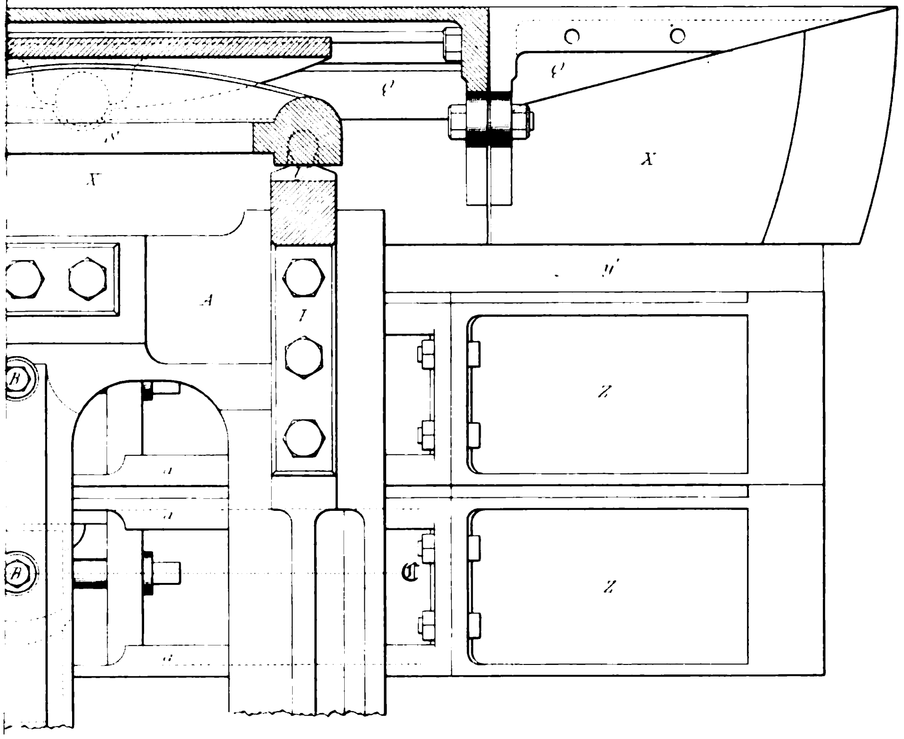
C. Coutts, sculp.

London, John Weale 1845.

the Saddle and Swivel.



of No 1, taken on the Line A. A.



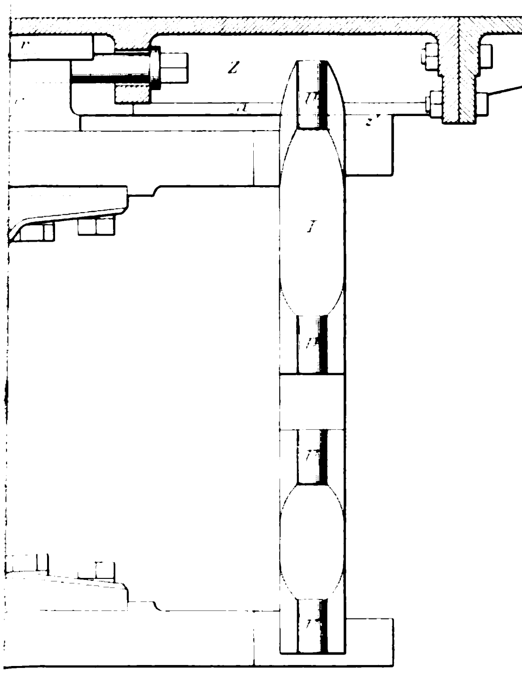


Fig. 7 — Plan of Saddle.

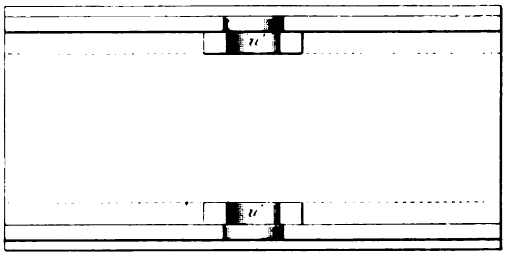
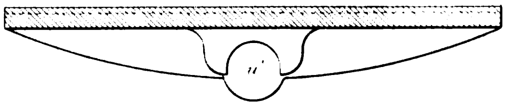


Fig. 8 — Section of Saddle.



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THAMES TUNNEL,

Details of the Shield.

Fig. 1.

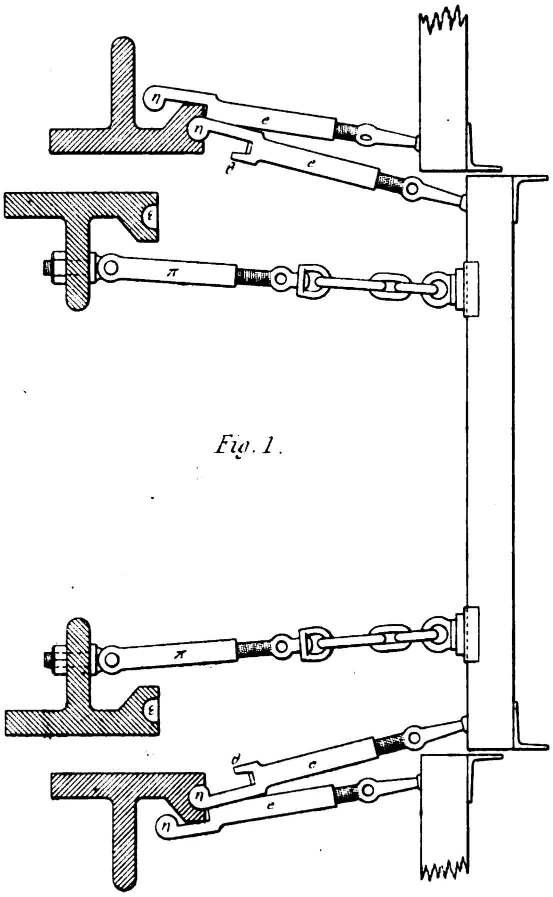


Fig. 3.

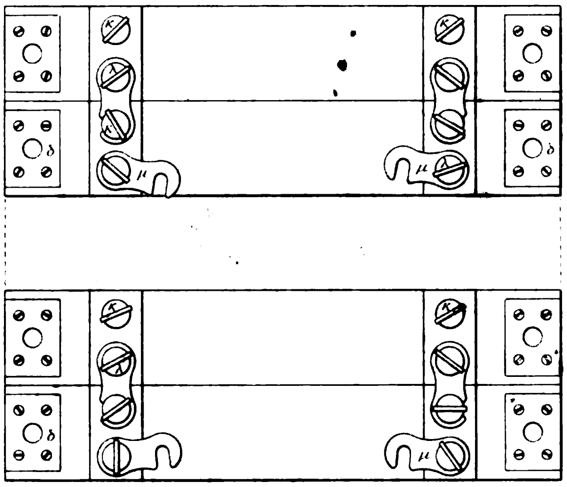


Fig. 2.

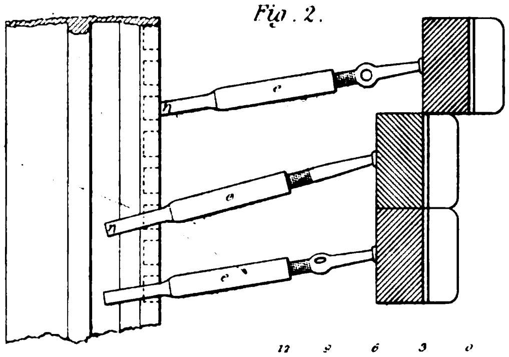
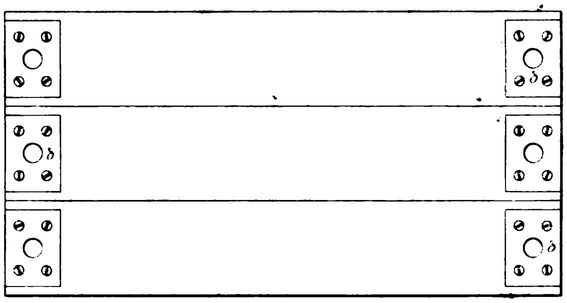


Fig. 4.



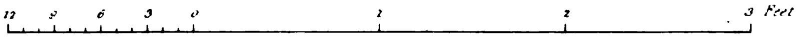
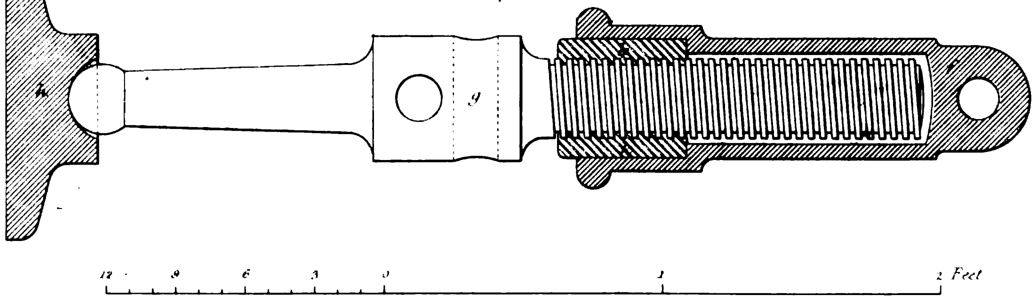


Fig. 5.

Section of the Top Abutment Screw.



London: John Weale, 1845.

THAMES TUNNEL.

Plan explaining the Advance of the Shield.

Fig. 1.

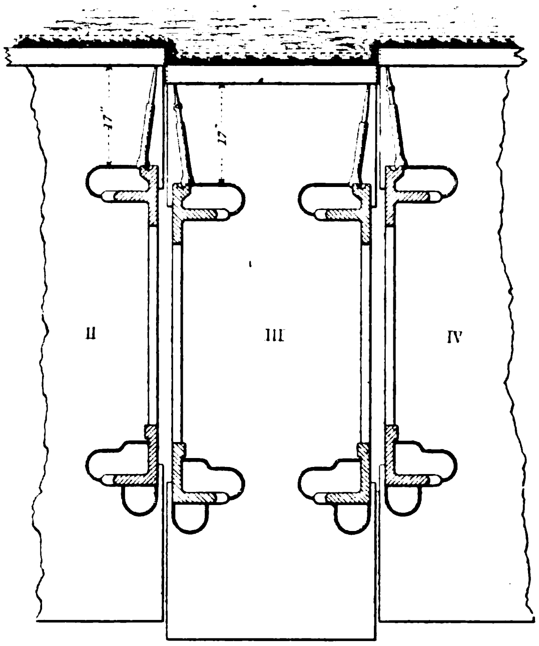


Fig. 2.

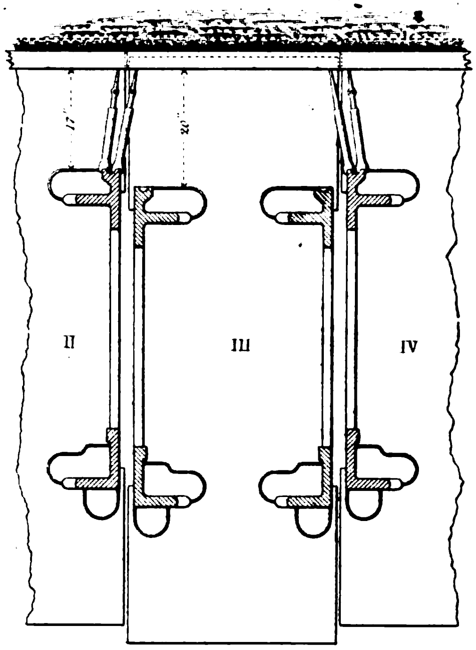


Fig. 3.

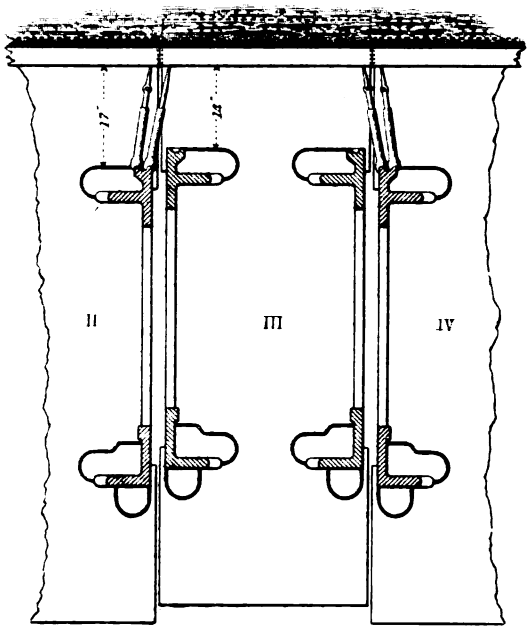
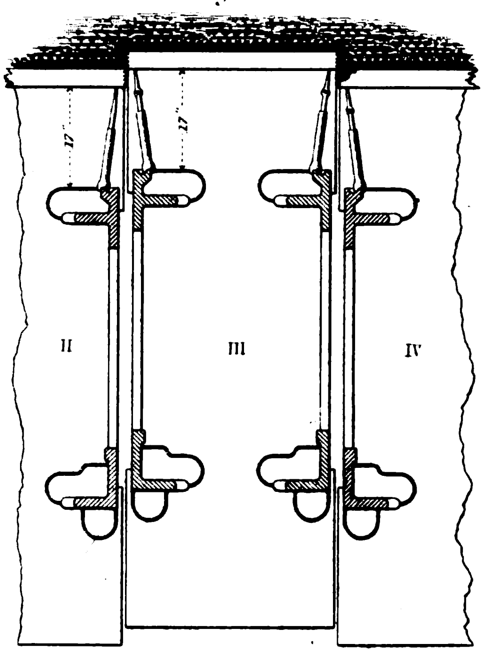
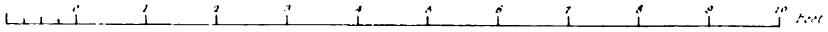


Fig. 4.





London, John Weale, 1845.

THAMES TUNNEL.

Details relating to the Progress of the Works.

Fig. 1.

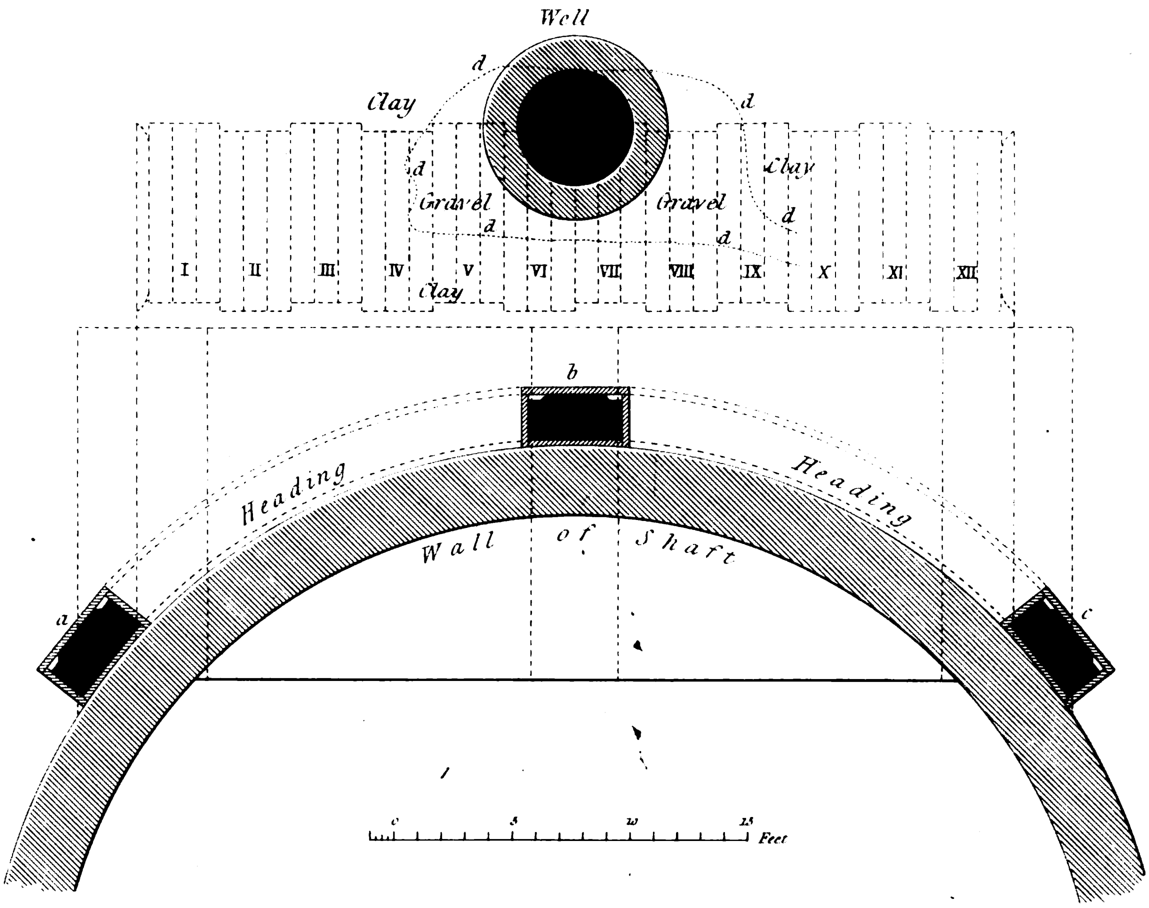


Fig. 2.

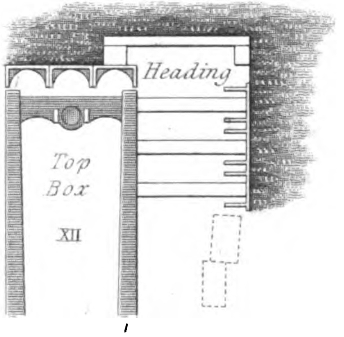


Fig. 3.

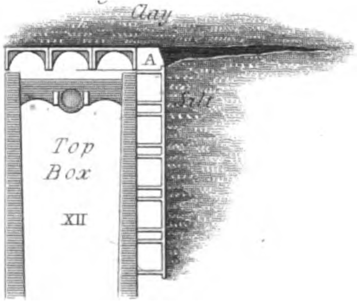
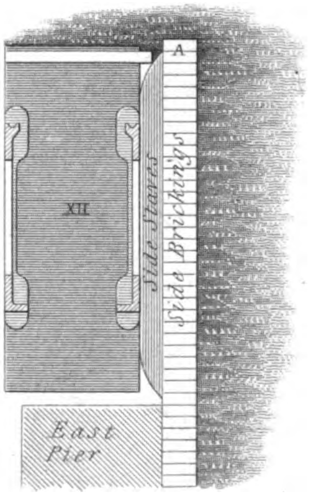


Fig. 4.



H. Law del.

G. Gladwin sc.

London John Weale. 1845.

THAMES TUNNEL.

Details relating to the Progress of the Works.

Fig. 1.

Heading in front of Nos VI & VII.

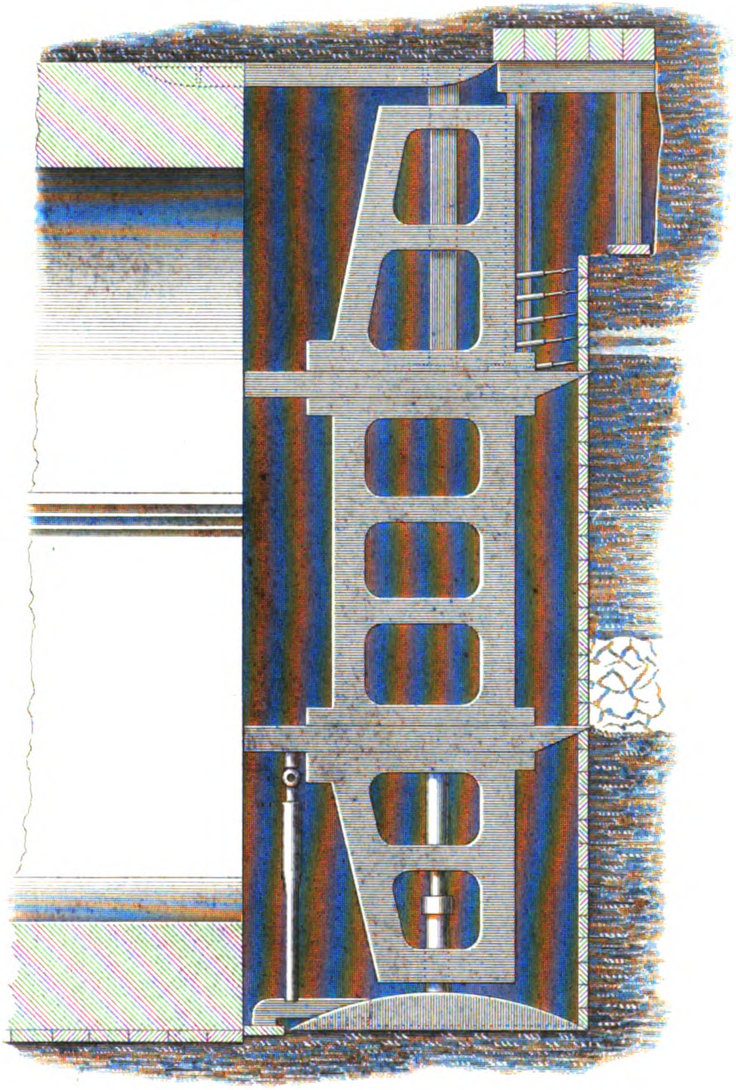


Fig. 2.

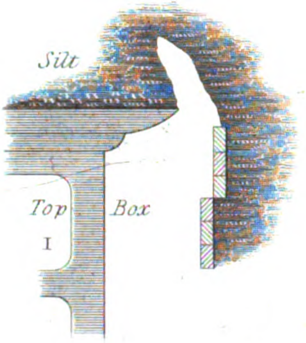


Fig. 3.

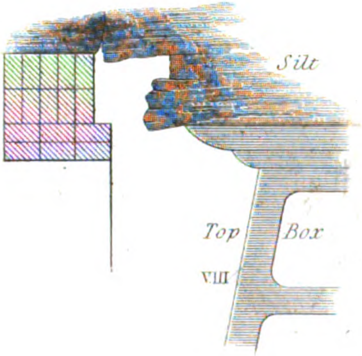


Fig. 4.

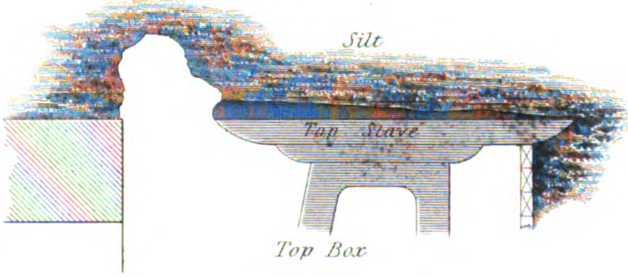
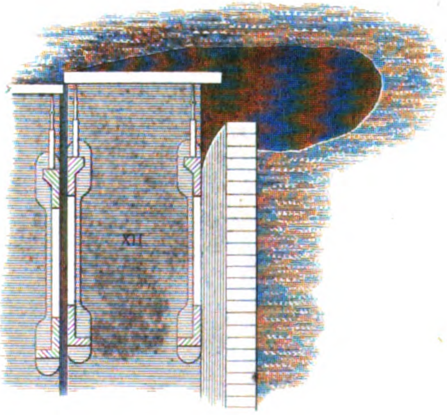
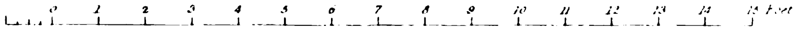


Fig. 5.





H. Law delin. [illegible]

London John Weale, 1845.

THAMES TUNNEL.

Details relating to the Progress of the Works.

Fig. 1.

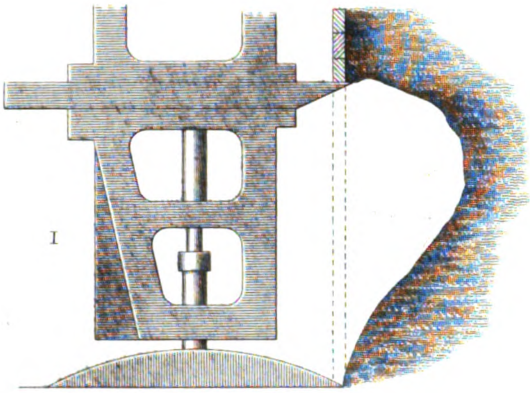


Fig. 3.

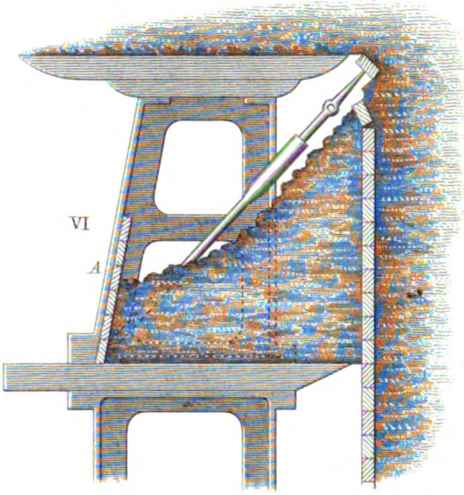


Fig. 2.

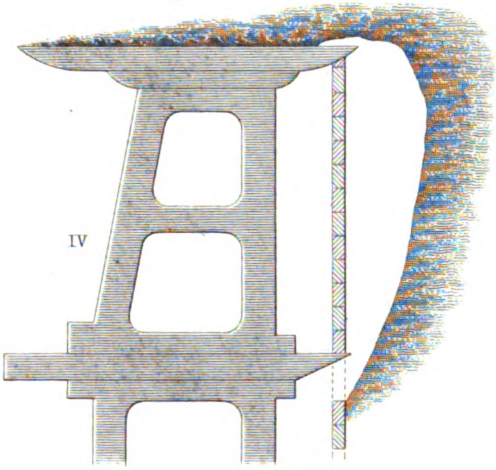


Fig. 4.

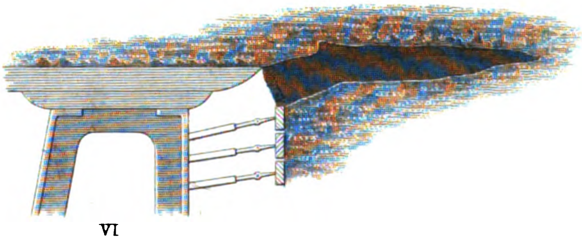


Fig. 6.

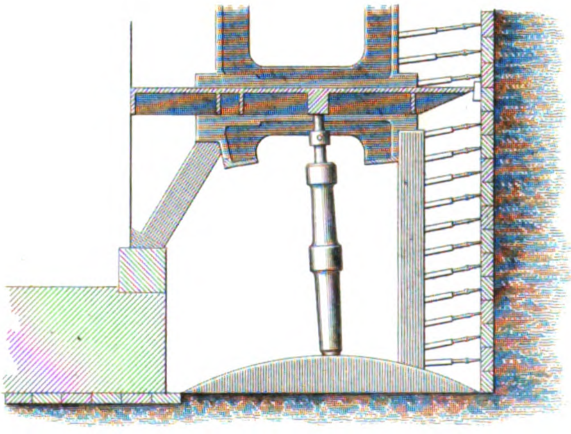
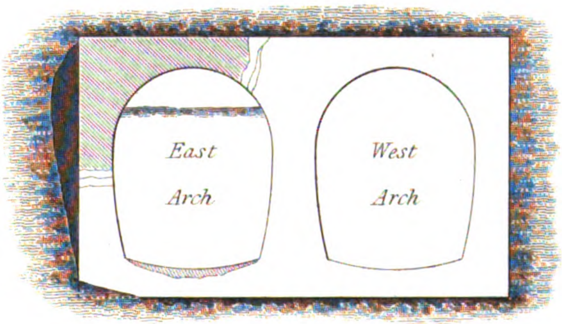


Fig. 5.



Scale for Fig 5.

10 5 0 10 Feet

Scale for Figs 1 2 3 4 & 6.

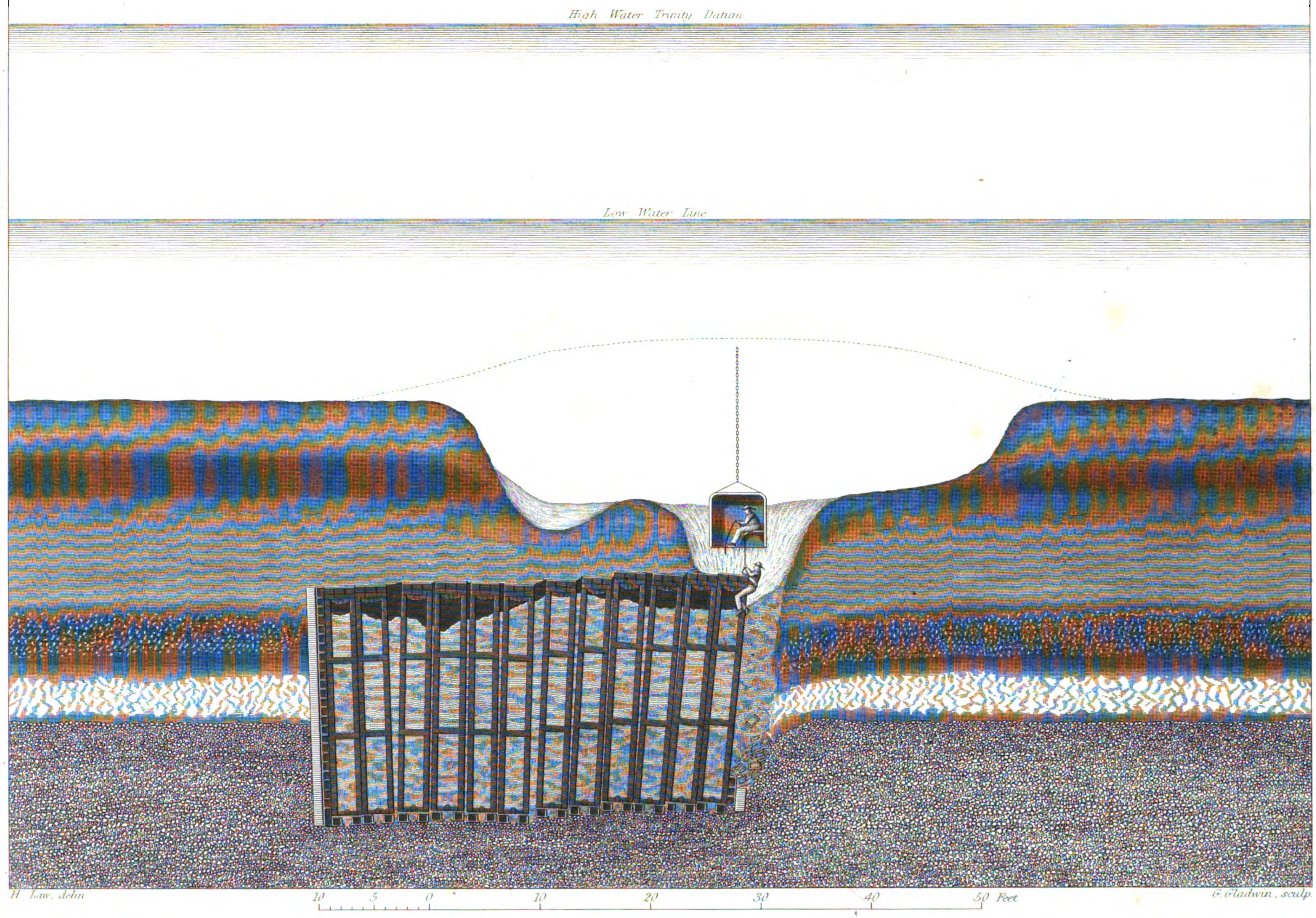
0 1 2 3 4 5 6 7 8 9 10 Feet

H. Law delin.

J. Gladwin sculp.

London, John Weale 1845.

Longitudinal Section of the Bed of the River after the First Irruption.



H. Law, delin

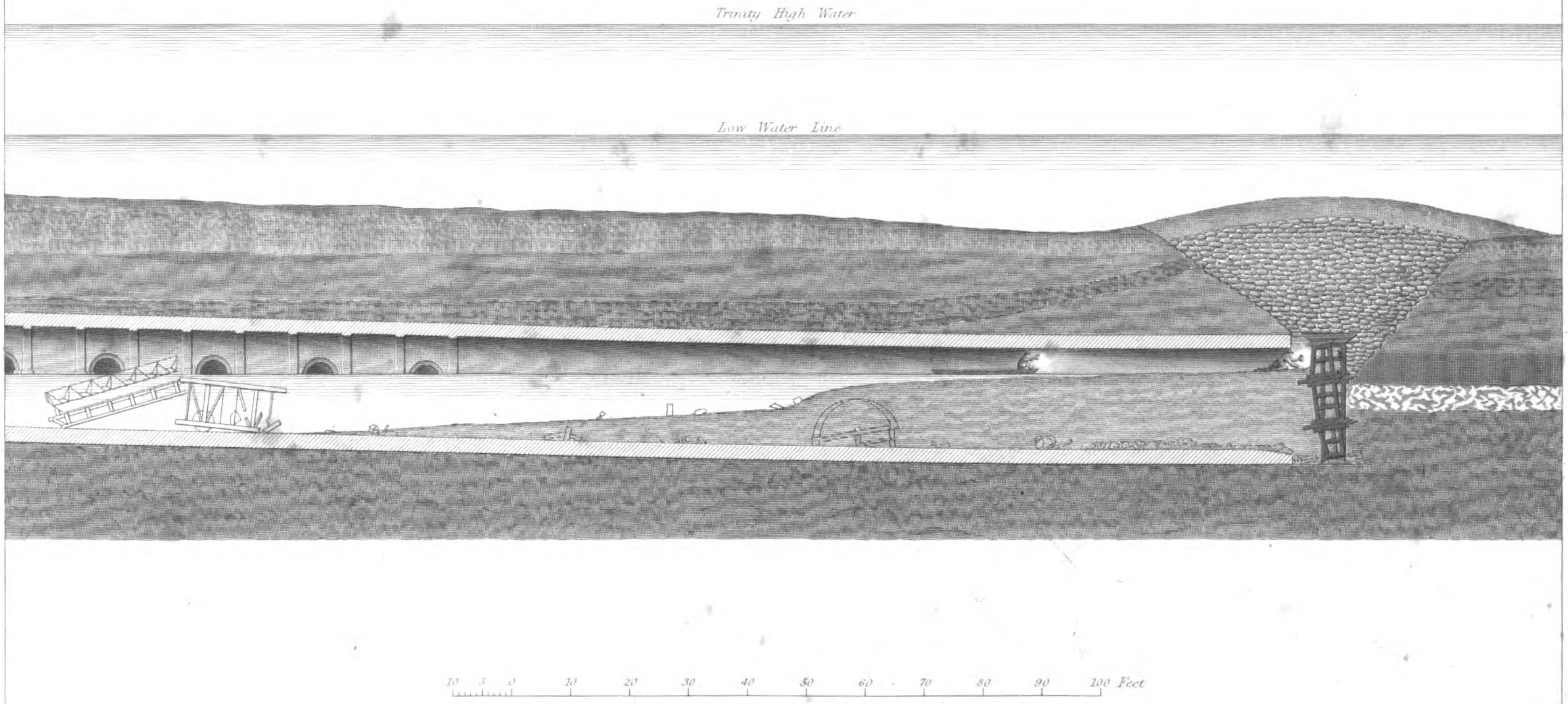
G. Gladwin, sculp.

London John Weale [illegible]

Plate 10

THAMES TUNNEL

Longitudinal Section, shewing the State of the East Arch, after the First Irruption



H. Law, delin. G. Gladwin, sculp.

London; John Weale, 1846.

REPORT OF THE INSTITUTE OF FRANCE

UPON

M. ARNOLLET'S SYSTEM

OF

ATMOSPHERIC RAILWAYS.

A

INTRODUCTION.

THE following views and objects have influenced me in translating and preparing for publication the annexed Report, by the Commission of the Institute of Paris, upon M. Arnollet's Memoir, which I have alluded to, with reference to my claim to priority of invention, in the Appendix to my three Reports upon new methods of producing vacuum for use upon atmospheric railways, as published in the last Part (Midsummer, 1845) of Mr. Weale's Quarterly Papers.

I have stated in that Appendix that the correctness and value of my views has, by the publication of the Report of the Commission, received the stamp of authority from Arago and its other distinguished members. It has seemed to me desirable to sustain this assertion towards the large class of persons in Great Britain interested in railway improvement, to whom French scientific publications are inaccessible. I have also thought it but due to myself to show how completely every point adverted to by M. Arnollet, or by the Commission of the Institute, has been anticipated by me, including the experiments of M. Le Maistre upon the economization of steam when used at distant intervals, by cutting off the air and out drafts of the fire, &c., for which my construction of boiler and furnace provides more perfectly than anything which appears by the notice of the Commission to have been done by M. Le Maistre.

My principal inducement, however, has been to make readily available to the English engineer the mathematical notes of M. Lamé, appended to the Report of the Commission.

There are few practical engineers in our own country that will not be disposed to smile at the engineering skill of the French savans, when with cautious gravity they doubt the practicability of making air-tight iron reservoirs, and "think that every impartial engineer will fence himself with the same reserve;" but however valueless their report may be in this and one or two other passages, its general accuracy and its putting, for the first time, a comparison of Clegg's with my method of producing vacuum for use on atmospheric railways, into a general mathematical form, renders the whole document of sufficient importance to assume a separate English dress.

In reading this Report, it will be necessary for those not familiar with French mechanical writers to bear the following remarks in mind:—

The word travail, which I have rendered "power," means the same thing as the "moment d'activité" of Carnot, the "quantité d'action" of Navier; it is the "mechanical power" of Smeaton, the "labouring force" of Whewell; that which is measured by the product of the whole resistance overcome, times the whole space through which it is overcome; and in the present Report it means the total theoretic power of the steam.

That which I have rendered "available power," means the actual power of the engine, or the former less by the impediments, as friction, &c., to the working of the machine.

The "work done" here means the actual power of the engine less by what is lost or consumed by the construction of each particular form of atmospheric railway vacuum apparatus; it is the "duty" of Clegg's and of my own, or so-called Arnollet's, different systems.

When therefore the reporters say that on the English (Clegg's) system "the available power is equal to the work done," and that on mine (Arnollet's) "there is a loss of available power of 40 per cent."—it by no means follows that the latter is not the more economical and advantageous method of working of the two, and for the plain reason that a loss of much more than 40 per cent. of available power may and must take place upon Clegg's system, by the lying idle of the vast and indispensable engine power between the times of transit of trains. In a word, the practical comparison must in every case be made between the original power of the steam, and the final work done upon the railway in a defined period.

The formulæ hereafter given, with the information contained in Professor Barlow's Report to the Board of Trade, and in those by myself in the preceding part, will enable this comparison to be effectually made in any given conditions of traffic, or periods of rest and work, upon proposed atmospheric railways.

The unit of "power" used by French authors is one kilogramme = 2.20548 lbs. avoirdupois raised one metre = 3.28089 feet English, which is the *kilogrammetre;* and their "cheval vapeur" is 75^{km} such units per second of time, which is pretty near our horse power of 33,000 lbs. 1 foot high per minute.

Before concluding, a remark seems requisite upon the opinion of M. Arago, quoted by the Commission as a set-off in favour of the English (Clegg's) system, viz., that "manufactures which ordinarily use the *uncertain powers* of *water* and wind, &c., will group themselves round the powerful engines of the English system, and use up their regularly disposable power," &c.

It is the first time that water power has been set down as uncertain ; our cotton and flax spinners find it much more regular than even the best steam-engine ; but if *it* be so, what sort of manufacture, of the slightest value or importance, could conceivably be supplied with power from a large engine, the whole of which would be liable at any moment, in the most uncertain and irregular way, to be thrown off from it, and diverted to the primary purpose of the atmospheric railway.

There is but one imaginable way in which this spare power can be brought to bear for thus "letting off at a rent," viz., by using it to accumulate a reservoir of power to be used by the rentors while the engine is at its legitimate work, either by pumping up water, or exhausting vacuum vessels to work other engines by meanwhile ; but as the best water-wheels only return about 60 per cent. of the power due to the fall, so there will be here inevitably 40 per cent. of the available power between trains wasted, and still more if the vacuum power stored up be thus used to actuate secondary engines. This supposed refuge, therefore, for the " English system " is based upon a mistake.

ROBERT MALLET,
MEM. INST. C. E.

Dublin, December 1st, 1845.

REPORT OF THE INSTITUTE OF FRANCE

UPON

M. ARNOLLET'S SYSTEM

OF

ATMOSPHERIC RAILWAYS.

Published in Paris, 7th April, 1845.

COMMISSIONERS—MESSRS. ARAGO, REGNAULT, AND LAMÉ, REPORTER[a].

The academy has required Messrs. Arago, Regnault, and myself to make a report upon a memoir presented by M. Arnollet, and concerning a new system of atmospheric railway. The idea of employing the rarefaction of air as a means of transport was started by Medhurst, a Danish engineer, in the year 1810. Since 1824 various unsuccessful attempts have been made to apply this idea, and at length an important invention of Clegg and Samuda has made this new mode of locomotion successful.

It is generally known that the system called the atmospheric, consists of a tube placed between the rails, in which a fixed steam-engine produces a partial vacuum; a piston in this tube is propelled by the excess of atmospheric pressure, and its motion is transmitted to the exterior of the pipe, by a straight bar, to which the longitudinal slit gives passage. It is requisite that a sort of continuous valve shall seal hermetically this slit in advance of the piston, shall open to let the bar pass, and shall close again behind it.

Clegg and Samuda were the first to fulfil these indispensable conditions in stopping the longitudinal orifice by a band of leather, properly strengthened, carefully sealed up, which is raised by rollers attached to the tail of the piston, which then falls back by its own weight, and so managed that hot cylindrical compressors pass over and seal it anew.

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[a] Translated from the "Comptés Rendus de l'Academie des Sciences," for 7th April, 1845, Vol. XX. page 1004.

This apparatus was tried in 1838, in small models, at Chaillot, and afterwards at Havre. More important trials were made in the neighbourhood of London by Clegg and Samuda, which were given an account of in France by M. Tesserenc, and which removed all doubt as to the possibility of the use of the atmospheric system.

Mr. Pim, Treasurer of the Dublin and Kingstown Railway, proposed, and was successful in applying, it upon the Kingstown and Dalkey Railway, of about three kilom. in length. The last experiment, made on a sufficient scale, has completely succeeded, and M. Mallet, Divisional Inspector of Bridges and Highways, has given a detailed description of it.

It is well known that an act of the legislature has authorized the Minister of Public Works to devote a sum of 1,800,000 francs to new experiments: such a measure must strongly excite the spirit of invention, and explains the cause of the great number of communications relative to atmospheric railways which have been made this year to the academy. We are at present, however, only to consider the memoir of M. Arnollet, which treats specially of economizing the cost of the establishment, (for obtaining vacuum, namely,) and of the power employed.

At the Dalkey Railway, the air-tube is directly exhausted by an air-pump wrought by a steam-engine. This apparatus works before and during the transit of a train, but then remains idle. Thus, according to the English atmospheric system, a very powerful engine works with great effect for eight or ten minutes, and then remains unemployed for an hour or more: it is, however, indispensable that the heat of the steam boiler be maintained in this interval, in order that the engine may be ready to start at any moment.

The loss, the outlay, and the other inconveniences which arise from this discontinuous working, have induced M. Arnollet to propose a different method of exhaustion. According to his system an engine of a few horse power will be constantly employed to rarefy the air in three reservoirs, having each a capacity at least equal to that of the air-tube, or in one of three times its capacity. When the pressure within these reservoirs is not more than one third of an atmosphere, communication will be made with the air tube, and thus at once a mean pressure of one half an atmosphere will be established in common. This exhaustion will cause the piston and train to traverse to the end of the course. The air altogether returned into the reservoirs will have now attained a pressure of two-thirds of an atmosphere, and the continuous action of the engine will again reduce this pressure to that of one-third of an atmosphere.

To point out the advantages of his system, M. Arnollet assumes a railway worked with a speed of 60 kilom. per hour, with an annual traffic of 2,500,000 tons, net weight, in passengers and goods, or 700 tons per day, divided into ten trains; the way divided into stations of 5,000 metres in length, each worked by a small constant engine (moteur atmospherique partiel). The author finds that it will require an engine of 126 horse power to exhaust the air of a tube 5,000 metres in length, and of 39 centimetres in diameter, if the English system be adopted, whilst by the application of the method which he proposes, an engine of eight horse power will be sufficient in the same circumstances, that is to say, that a power sixteen times less will be enough[*]. These numbers assume that the long valve is absolutely air-tight.

M. Arnollet deduces from many experiments, reported by M. Mallet, that the apparatus at Dalkey leaks to the extent of 15 cubic metres of air per kilometre (of tube) per minute; and adopting this datum, the author finds that the power of his engine must be extended from eight to ten horse power; but as this defect of the apparatus and the loss of power which it occasions have not as yet been sufficiently considered, we shall neglect it in comparing the two systems.

Several notes added to the present report give for both cases the calculation of the power employed, and of the effect obtained. In the English system the available power expended, however the engine works, is exactly equal to the work obtained. The loss of power, therefore, is precisely that which is due to the fuel burnt to waste during the period of rest, or while the engine is standing idle: thus, if we take one-third of an atmosphere for the density of air in the tube, we find that the engine must be at work for a time about double that occupied by the train in running over the distance between the two stations; the first half of this time is employed in exhausting the air of the tube before the starting of the train, from the external density to that of one-third of an atmosphere.

Upon the system proposed by M. Arnollet, however, if we adopt one-third of an atmosphere for the density which the engine leaves in the reservoirs, our calculation shows that the available power is to the work done in the ratio of five to three, from which it results that there is a loss of force of 40 per cent.; this loss arises when communication is made between the three reservoirs in which the density is one-third of an atmosphere, and the tube full of air at common pressure—in order to obtain a mean density of half an atmosphere; for if it had been possible to exhaust directly the half of the air contained in the four volumes together, (i. e. the tube = 1, and the reservoirs = 3,) which would have resulted as in the English system in an equality between the power expended and the work done, we should obviously have expended less power in expelling the three first sixths of air contained in the tube, than in expelling, as is unavoidable, the fourth sixth of air from the three reservoirs.

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[*] See Note IV. at the end of this Report.

In fact, the two first thirds of the original volume of air contained in the reservoirs are expelled once for all, but the air in the tube, packed up by the travelling piston, comes in to replace the second third of this original volume, and it is the power employed to expel this afresh that constitutes the whole of the available power expended for the passage of each train; but we find by calculation, and it will be readily admitted, that we shall reduce this power at least 40 per cent., by substituting for the exhaustion of the second half, and more difficult portion of the whole volume to exhaust, that of the comparatively easily exhausted first half of the air contained in the tube, a substitution which would render it (the available power) precisely equal to the work done.

According to these theoretic results, supposing the original outlay for both sorts of apparatus were equal, if the periods of running of the trains are in very rapid succession, or if sufficient precautions be taken that the fuel consumed by the engine, while resting idle, (on the English system,) shall not be more than two-thirds of that burnt during the portion of time it is at work, the two systems will then be upon a par, and there will be no reason to prefer one more than the other on economical grounds.

Such are the simple conditions to which the comparison of the two systems reduces itself, whatever may be in other respects the distances between station and station, the speed of trains, the tractile force due to this speed, the weight carried, or the amount of gradients.

Is it then really impossible that the English system can fulfil the required conditions, so that its cost shall not exceed that of M. Arnollet's system? This question we are unable at present to answer. Practical data are wanting to enable us to compare the costs of the two sets of apparatus. We know the cost of the powerful steam-engine required on the English system, and that of the air-pump apparatus, not less costly, which it works; but upon M. Arnollet's system, besides his very small engine and air-pump, three substantial and air-tight reservoirs must be constructed, of the cost of construction of which it appears difficult if not impossible to form any estimate; the capacity of each of these vessels must be, according to M. Arnollet, from 600 to 800 cubic metres, but in reality far greater, as we shall presently prove; it is indispensable that these shall not only be absolutely air-tight, but so thick and strongly stayed as to resist the external pressure tending to crush them, and amounting to a pressure of about seven tons on each square metre of their surface. Would then the cost of three such reservoirs be less than the difference in cost between the engines and air-pumps upon the two systems? This we cannot, à priori, say, and we think that every impartial engineer will fence himself with the same reserve.

Many practical men have lately proposed to discover the best means for diminishing as much as possible the expenditure of fuel during the idle intervals of the steam-engine.

We may notice a remarkable experiment made upon a common boiler, in the workshops of M. Le Maistre, at La Chapelle. According to this several times repeated experiment, a stoppage of one hour, followed by a blowing off of steam for ten or twelve minutes, only produces an increase in the consumption of fuel amounting to one third; during the stoppages, the boiler flues were carefully stopped up, both at the ash pits and outlets; while blowing off, on the contrary, they were all open, and the fire was urged by a fanner for two or three minutes. If this fact be verified, the expenditure of fuel is not a serious objection to the English system. Besides, the loss of power which the wasted fuel represents may disappear altogether, for as one of us, M. Arago, has in another place expressed his opinion, the manufactures which ordinarily make use of the uncertain powers of water and wind, and others besides, will group themselves round the powerful engines of the English atmospheric system, and thus use up their regularly disposable power, otherwise unemployed, and this circumstance will render it the less costly. It will be quite otherwise with the excess of power expended in the system of M. Arnollet, which will be irretrievably lost, and without profit to any one.

The calculations which have served for the base of the comparison which we have come to establish, neglect several causes of loss of power, such as the leakage of air through the valves, the inequalities of pressure which must exist in the atmospheric main, the heating of the body of the air-pump by the compression of the expelled air and consequent dilation of the air drawn into it,—all of these conditions requiring an augmentation of the power expended; but we want data to enable us to value these with precision, and besides, they must apply to both systems.

Altogether, however, we must admit that the system of M. Arnollet is in better condition to diminish the losses of power than the English system.

The time during which the long valve remains exposed to leakage into the vacuum is shorter. When the air of the reservoirs is once exhausted, the inequalities of pressure (on the travelling piston) will be incomparably less than when the long narrow tube alone is directly exhausted, as in the English system; and lastly, the much longer time of action of the moving power, and the relative diminutiveness of the air-pump, enable its dimensions to be increased, and its speed retarded, so as thus greatly to diminish the heating of the body of the pump.

M. Arnollet appears to assume in his memoir that a force of traction of four kilogrammes per ton, which is fully sufficient to start the train, will suffice also when its speed is 60 kilometres per hour, or 16.65 metres per second. This number is evidently much too small.

Many observations made upon the railways in the neigbourhood of Paris have led to a much more convenient empirical formula to represent the co-efficient of traction. This formula, which is composed of a constant term, and of another proportional to the square of the velocity, gives a traction of 13 kilogrammes per ton for a velocity of 16.65 metres per second. It has been observed upon the Versailles (left bank) Railway, that a train descending freely upon an incline of one in one hundred, acquires an uniform velocity of 13 to 14 metres, which gives 10 kilogrammes per ton for the traction due to this velocity. These two numbers are evidently concordant, but they are certainly too great when the trains are very heavy, because the formula above alluded to supposes that the increment of total traction, which results from the velocity, is proportional to the weight of the train,—which cannot be so, since the resistance of the air, upon which the increment depends, must act principally upon the carriages in advance, and hence must augment very feebly in relation to the number of those which follow.

Adopting, however, the traction of 13 kilogrammes per ton, which represents the limit opposed to that of four kilogrammes, and using the formulæ given in the notes annexed to this report (see Note IV.), we find that to obtain a velocity of 60 kilogrammes per hour, with trains of 120 tons total weight, we must for each station or length of main of 5,000 metres only, have a steam engine of 200 horse power, or one of 20 horse power, with three reservoirs, each having a capacity of 2,000 cubic metres, or 6,000 cubic metres in all. This would be, on both sides, to purchase too dearly the advantage of giving to an enormous mass an excessively great velocity, of which the dangers are so frightful, and without remedy.

With trains of 50 or 60 tons or more, and with a velocity of 30 to 40 kilogrammes per hour, the cost will be three or four times less, and the formidable character of accidents will disappear. Economy and prudence are here united in assigning a limit to the exaggeration of the advantages which railways offer.

Notwithstanding the uncertainty which does not permit us as yet to recognise the superiority which M. Arnollet attributes to his system, under all circumstances, we think, nevertheless, that even now this system can be applied with advântage upon a railway destined to be worked with trains at distant intervals of time, and moving with a moderate velocity, especially if it be possible to arrange the trains so as to have equal intervals of time between them during the twenty-four hours of day and night.

Whatever may be the result, the memoir of M. Arnollet, which contains useful remarks and ingenious views, treats of an important question, which experience and practice can alone completely resolve.

The conclusions of the report are adopted.

NOTES ANNEXED TO THE PRECEDING REPORT, BY N. LAMÉ.

1st. Calculation of the Power necessary to rarefy the Air contained in a Tube of the length Λ, and of the Section S, from the barometric Density H, to the reduced Density η.

We will assume the tube to have a fixed bottom, taken for the origin of x, and that it is closed towards its other end by a moveable piston, P, beyond which the tube is indefinitely prolonged.

We readily perceive that the power sought is equal to that which will be required to draw out the piston P, placed originally at a distance $x = \frac{\Lambda \eta}{\text{H}}$, from the fixed bottom to the distance Λ. H being the density of the air contained in the tube of the length $\frac{\Lambda \eta}{\text{H}}$, let p be the elastic force of this air for any length, x; we then have

$$p = \frac{\Lambda \eta}{x} \quad \text{or } \text{H} - p = \text{H} - \frac{\Lambda \eta}{x}$$

and the power sought will be given by the definite integral.

$$\int_{\frac{\Lambda \eta}{\text{H}}}^{\Lambda} \text{S}\left(\text{H} - \frac{\Lambda \eta}{x}\right) d\,x = \text{S}\,\Lambda\left(\text{H} - \eta - \eta \log. \frac{\text{H}}{\eta}\right). \qquad (1)$$

2nd. Calculation of the Power expended and of the Work done in the English Atmospheric Railway System.

Let L be the length of the tube, h the density of the air which it contains at the starting of the train; the power expended then will be composed of

$$\text{T} = \text{S}\,\text{L}\left(\text{H} - h - h \log. \frac{\text{H}}{h}\right)$$

the power employed to exhaust the air of the tube from H to h, and independent of the power

$$T' = SL(H - h)$$

requisite to pull back the piston, P, through the distance, $L' = L$, supposed to be taken in an additional length of tube, diminished by the power T'', which will be restored by the piston P, returning through the tube L', when the air which it contains shall be restored from the density h to that of H.

The expression for the value of this power then will be

$$T = \int_{\frac{Lh}{H}}^{L} S\left(H - \frac{Lh}{x}\right) dx = SL\left(H - h - h \log. \frac{H}{h}\right).$$

The power expended is then $(T + T' - T'')$, or simply $T' = SL(H - h)$, since $T'' = T$.

But the work actually done by the travelling piston dragging the train, is also $SL(H - h)$. Hence we conclude that in the English system, the available power expended, however the engine work, is exactly equal to the work done.

If we take $h = \frac{1}{3}H$ we have

$$T = \tfrac{1}{3} SLH\,(2 - \log. 3) \qquad SL(H - h) = \tfrac{2}{3} SLH.$$

Thus the power expended to form the vacuum in the tube before the starting of the train is to the whole power as $(2 - \log. 3)$ is to 2, or since the hyperbolic logarithm of 3 is $= 1.09861$ – the time of working of the engine is to the time of transit of the train as 2 is to 1.09861, that is to say a little more than double, or more exactly, as $9 : 5$.

3rd. CALCULATION OF THE POWER EXPENDED AND OF THE WORK DONE IN M. ARNOLLET'S SYSTEM.

Let H be the external or atmospheric density, h the elastic force of the air exhausted or rarefied in the three reservoirs before they are put into communication with the tube of the length L, and of the section S; h' the mean density obtained in the tube and reservoirs when communication having been established the train is just about to start. Lastly, let h'' be the density of the air in the reservoirs alone on the coming in of the train.

Each of the three reservoirs having the same capacity with the tube, we will suppose with M. Arnollet that

$$H = 3h = 2h' = \tfrac{2}{3}h'' \qquad (2)$$

The power expended in exhausting the air of the three reservoirs from H to h is according to the formula (1)

$$3\,S\,L\left(H-h-h\log.\frac{H}{h}\right)=S\,L\,H\,(2-\log.3) \qquad (3)$$

When communication has been opened between the tube and reservoirs, and the mean density $h'=\frac{1}{2}H$ has been established, there results a loss of power; for in fact we had obtained the same density h' when we exhausted directly from H to h' the air contained in the three reservoirs and the tube, both communicating freely. This only required a power of

$$4\,S\,L\left(H-h'-h'\log.\frac{H}{h'}\right)=S\,L\,H\,(2-\log.4) \qquad (4)$$

and equation (3) exceeds that (4) by

$$S\,L\,H\log.\frac{4}{3} \qquad (5)$$

which is the available power thus found to be lost. We may discover also this loss by comparing as follows the power obtained with the work done.

In order to calculate the power made available (or the useful power) by the transit of the train through the tube L, let p be the density of the air which it contains, at some given moment of the transit; x the distance at this moment between the travelling piston and the fixed bottom placed at the extremity of an additional tube of the length $3\,L$ placed beyond the point of arrival of the train, and which thus represents the capacity of the three reservoirs; we have then

$$p\,x=2\,L\,H \text{ or } H-p=H\left(1-\frac{2\,L}{x}\right),$$

and the power made usefully available will be

$$\int_{3\,L}^{4\,L} S\,H\left(1-\frac{2\,L}{x}\right)dx=S\,H\,L\left(1-2\log.\frac{4}{3}\right).$$

When the train has passed, (i. e. the point separating L from $3\,L$,) we must exhaust the air of the three reservoirs from the density $h''=\frac{2}{3}H$ to the density $h=\frac{1}{3}H$. We shall obtain the value of the power required to produce this effect by subtracting from equation (3) the power which will exhaust the air of the reservoirs from H to h''. This gives

$$3\,S\,L\left(H-h-h\log.\frac{H}{h}\right)-3\,S\,L\left(H-h''-h''\log.\frac{H}{h''}\right)=S\,L\,H\left(1-\log.\frac{4}{3}\right).$$

Thus the transit of each train demands $S\,L\,H\left(1-\log.\frac{4}{3}\right)$ in available power expended, and only reproduces in work done

$$\text{S L H}\left(1 - 2 \log. \frac{4}{3}\right)$$

from which results the loss shown in equation (5).

But looking for the hyperbolic logarithm of $\frac{4}{3}$ we find

$$\log. \frac{4}{3} = 0.28768$$

$$1 - \log. \frac{4}{3} = 0.71232$$

$$1 - 2 \log. \frac{4}{3} = 0.42464$$

Thus the last number is a little less than three-fifths of the second, from which we conclude that in M. Arnollet's system the available power expended is to the work done, in the ratio of five to three, or in a word, that the system occasions a loss of power of 40 per cent.

4th. CALCULATION OF THE POWER OF STEAM ENGINE REQUIRED ON BOTH SYSTEMS.

When the speed of the train is 60 kilometres per hour, and that we adopt the measure of traction at 13 kilogrammes per ton, the work done in a second of time by the transit of a train of 117 tons total weight, is equivalent to 13.117, or to 1.521 kilogrammes raised 16.65 metres, or to 25.350 kilogrammes raised one metre. The latter number divided by 75, gives exactly 338 horse power for the locomotive power required to draw a train of 117 tons 5000 metres in five minutes.

On the English atmospheric railway system the same effect would be produced by an engine working *without loss of available force* during nine minutes. The power of the engine would then be $\frac{5338}{9} = 188$ horse power.

On M. Arnollet's system, supposing a stoppage of an hour and a half per day, there will remain 22 hours 30 minutes for accumulating the power requisite for the passage of 10 trains, 135 minutes for each, or 27 times the time of its transit. Recollecting that this system loses 40 per cent. of the available power expended, we shall find $\frac{5}{3} \times \frac{338}{27} = 21$ horse power only will be required to do the same work, or *one-ninth of the engine power required upon the English system.*

The section of the atmospheric main, and hence the capacity of the reservoirs, must be at least triple those assumed by M. Arnollet, since the measure of traction must be taken at 13 kilogrammes, in place of four kilogrammes per ton.

THE TAUNUS RAILWAY.

FRANKFURT TO WIESBADEN.

STATION AT HÖCHST, VIEW FROM THE RAILWAY.

NOTE.—Where the letter M is placed denotes French metres = 3.280 feet English; fl. is florins, containing 60 kreuzers, or 1*s*. 8*d*. sterling; χ is kreuzers, 3 of which = 1 penny; ft. and inc. are feet and inches, English measure.

THE Taunus Railway, so named from its running nearly parallel with, and being in the vicinity of, the Taunus Mountains between Frankfurt-on-Maine and Wiesbaden, was constructed by Mr. Paul Denis, and fully opened to the public in the month of April, 1840, some portion of it being opened in September and November the previous year.

The building of the railway commenced in the summer of 1838. The line runs through three different territories: 1st, commencing in and running through part of the Frankfurt; 2nd, through part of the Duchy of Nassau; and 3rd, through the Grand Duchy of Hessen Darmstadt, for a short distance going through the fortress at Castel, and lastly entering Nassau again.

The Company received their concession from the Senators of the free town of Frankfurt on the 8th of May, 1838; from the government of Hess Darmstadt, 11th May; and from Nassau, 13th June; but not before 19th October the same year from the Military Commission[a] to go through the fortress at Castel; and in many parts the grounds could not be taken possession of before the summer of 1839, so that the line has been forwarded very expeditiously.

The railway is 41,858^{m} long = 26 English miles[b], not taking into account the branch line to Biebrich, which is 1,454^{m}, making together 43,312^{m}, or 27 English miles. There are six intermediate stations, viz., Höchst, Hattersheim, Flörsheim, Hocheim, Castel, and Biebrich; the first four and last of these being in the Duchy of Nassau, the station Castel in the Grand Duchy of Hessen Darmstadt.

The line runs nearly parallel to the river Maine, which at once almost vouches for the very few engineering difficulties which were met with. Great praise is, therefore, due to the projectors and engineers for their choosing such easy ground to pass over, the benefits of which the shareholders are now reaping. With the exception of parts of the line which run through the celebrated Hock vineyards, the grounds were bought at a moderate rate.

CAPITAL AND COST OF RAILWAY.

The capital of 3,000,000 fl. = £250,000, was raised by 12,000 shares of 250 fl. each = £20 16*s.* 8*d.*

The engineer's estimate was 2,300,000 fl. = £191,666 11*s.* 4*d.* But the sum of 3,000,000 florins not being sufficient to furnish or stock the railway, a loan of 300,000 fl. = £25,000, was granted, which raised the capital of the Company in 1840 to the sum of 3,300,000 fl. = £275,000.

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[a] Military Commission of the Confederation.

[b] This is the length the locomotives run, or length of rails; the total length, including the stations, is about 41,966^{m}.

The outlay is as follows :—

		FL.	x		£	s.	d.
1st.	For surveying, measuring, engineering, &c.	175,295	42	=	14,604	19	6
2nd.	„ earth-work, &c.	208,865	55	=	17,405	9	10⅓
3rd.	„ bridges and culverts	136,093		=	11,341	1	8
4th.	„ walling	21,041	34	=	1,753	9	3⅓
5th.	„ ballasting for sleepers to rest upon	67,075	50	=	5,589	13	0⅓
6th.	„ stone blocks and oak sleepers	203,060	10	=	16,921	13	7⅓
7th.	„ malleable iron rails	592,090	45	=	49,340	17	11
8th.	„ cast-iron chairs	140,191	48	=	11,682	13	0
9th.	„ iron nails, oak keys, and douls	24,553	44	=	2,046	2	10⅓
10th.	„ felts for underneath chairs	2,661	55	=	221	16	6⅓
11th.	„ laying rails, chairs, &c.	44,371	40	=	3,697	12	9⅓
12th.	„ 25 switches, crossings, and points	13,006	16	=	1,083	17	2⅓
13th.	„ turnpike and cross roads	16,962	41	=	1,413	11	1⅔
14th.	„ fencing, warning tables and posts, &c.	35,875	7	=	2,989	16	10⅓
15th.	„ 16 large and 13 small turn tables	42,567	19	=	3,547	5	6⅓
16th.	„ building stations and watch-houses	318,162	8	=	26,513	10	2⅓
17th.	„ boundary stones	1,321	55	=	110	3	2⅓
18th.	„ extra excavations, buildings, and foundations, in going through the fortress at Castel	13,225	3	=	1,102	1	9
19th.	„ 6 water reservoirs of cast iron, with pumps and water cranes, &c.	7,935	2	=	661	5	0⅔
20th.	„ work formerly not taken into consideration	6,675	26	=	556	5	8⅔
	Total outlay for building railway	2,071,000	00	=	172,583	6	8

TO BE DEDUCTED.

		FL.	x						
1st.	For material not used	34,609	19	52,909	46	=	4,409	2	11⅓
2nd.	„ ballast waggons and building materials	18,300	27						
	Total cost of building			2,018,090	14	=	168,174	3	8⅔

	FL.	χ		£	s.	d.
Brought forward .	2,018,090	14	=	168,174	3	8⅔
For lands in Frankfort, Hesse, Darmstadt, and Nassau	633,000	0	=	52,750	0	0
„ 6 locomotives, tenders, and duplicates .	174,568	27	=	14,547	7	5
„ 87 carriages, 21 goods and cattle trucks .	253,777	53	=	21,148	3	1⅔
„ expenses for administration	56,000	0	=	4,666	13	4
„ workshops, tools, &c.	24,001	23	=	2,000	2	3⅔
	Fl. 3,159,437	57	=	£263,286	9	11

This is the total cost up to the first general meeting of the shareholders, 12th August, 1840.

At the present time the Company have 12 locomotives and tenders, 99 passenger carriages, and 45 trucks and close luggage vans, 12 of the latter coming into this year's account.

	FL.	χ		£	s.	d.
Cost for 4 close luggage vans	7,114	28	=	592	17	5⅓
„ 8 transport waggons for cattle and merchandize	11,750	56	=	979	4	10⅔

At the last general meeting, which took place 17th April, 1845, according to the report given by the Board of Directors, the capital of the Company was 3,571,499 fl. 45 χ = £297,624 19*s.* 7*d.*, for the year ending 31st December, 1844.

EARTH-WORKS.

There are no heavy cuttings or embankments of any consequence upon the whole line. The only embankments worth noticing are, one between the river Nied and Höchst, which is about 1,500^{m} long, and at the highest part about 20 feet. The earth to build this embankment was taken out of a piece of ground by the railway side, bought by the Company for that purpose.

The next, after getting through Hattersheim, of about 1,200^{m} long and 10 feet high. The earth was partly taken from a short cutting between Hattersheim and the embankment, but by far the greatest portion was taken, as before, from a piece of ground by the railway side.

The part running through the vineyards near Hocheim is built upon a sloping ground, supported by a strong stone wall on the under side; the bank sides and small cuttings were taken to fill the space and level it. There is also, before entering the vineyards, another small embankment of about 1,900^m long, and 6 to 10 feet high; and upon leaving the vineyards, another small cutting which was used for the above.

The next embankment, between Hocheim and Castel, about 2,000^m long, and about 6 to 10 feet high, was taken partly from the cutting of a hill side, and the other part as before from a piece of land bought for the purpose.

Between Castel and Wiesbaden there is one more cutting, and two embankments, the two latter being together about 2,000^m long, and 10 to 12 feet high; the cutting about 500^m long and 8 to 10 feet deep, the proceeds of which were taken for making the above embankments and the Biebrich branch line, of which about two-thirds is also embankment; the wanting material, as before, was taken from ground near the railway. The ballasting of the whole line was taken in a similar manner, from patches of ground found suitable for that purpose, which, on some sections, cost much leadage.

GAUGE, RAILS, ETC.

The gauge is the narrow one, of 4 feet 8½ inches, and the rails of the double T form, weighing 58 lbs. per yard, of Welsh manufacture, contracted for by the Messrs. Goldschmidts, of Frankfurt and Mainz, iron merchants, &c., and delivered at £16 per ton. The joint chairs weigh 22 and the intermediate 19 lbs. each.

Where embankments are raised, the chairs rest upon oak sleepers 8½ feet long, being trees of 12 to 16 inches diameter, cut through the middle; each sleeper cost 2 fl. or 3*s.* 4*d.* sterling; and in cuttings, or where no embankments are, they are laid upon stone blocks, 2 feet square and 12 inches thick, felt being laid between the chair and stone; the cost of each stone is 2 fl. 30 χ or 4*s.* 2*d.*

Since the commencement the permanent way has cost very little repairs, with the exception of one or two places, which were damaged by heavy rains and floods; but between the two systems of wood and stone the latter has cost considerably less than the former.

The earth-works, bridges, and culverts, are finished from Frankfurt to Castel for double way, but as it is not necessary at present to lay down the second line of rails, the grounds are mostly cultivated, and sown with clover, which, as well as the slopings, yield a pretty little capital.

BRIDGES AND CULVERTS.

There are upon the whole line of railway, including the Biebrich branch, 16 bridges and 113 culverts, which, although they cannot boast of any great beauty, make up for it by their strength and durability.

The three largest bridges contain three, four, and six arches respectively; the first over the river Nied, with three of 10^{m} span each, and 7^{m} high; the second with four arches, used as a fieldway, underneath the embankment between the Nied and Höchst, 5^{m} span, and $5\frac{1}{2}^{m}$ high; the third underneath the same embankment, also used as a fieldway, with six arches of 5^{m} span and $5\frac{1}{2}^{m}$ high. The others are all smaller, containing from one to three arches, and 4^{m} to 5^{m} span.

There are also two large wood bridges, one on entering and one on leaving Castel, thrown over the trenches of the fortress; these are supported upon two stone pillars in the middle, or between walls. The length is 70 feet and breadth 24 feet, there being a double row of rails laid upon them. The reason of these being built of wood is, in case of war breaking out they can be easier demolished or removed than when built of stone.

The station house in Castel is also a wood building, for the same reason.

GRADIENTS AND CURVES.

The curves upon the main line are nine in number, but from the great radius of some of them they might almost be counted a straight line. The nine curves are divided into thirteen, having each a different radius.

To take them by rotation, with gradients, from station to station, they stand as follows:—

1st. From Frankfurt to Höchst 8900.75^{m}, being a straight line, with four descents and one ascent.

The first descent is $4,060^{m}$ long, descending $\frac{1}{1500}$; second, $2,800^{m}$ long, $\frac{1}{3400}$; third, 380^{m} long, $\frac{1}{800}$; and fourth, 300^{m} long, $\frac{1}{674}$; then ascending $1,540^{m}$ long, $\frac{1}{275}$, which is the greatest inclination on the whole line of railway.

2nd. From Höchst to Hattersheim 5927.35^{m}, having one curve of $2,300^{m}$ long, and $2,648^{m}$ radius, with four descents, one ascent, and one plane. The first descent $1,140^{m}$ long, $\frac{1}{1000}$; second, 720^{m} long, $\frac{1}{5833}$; third, $2,400^{m}$ long, $\frac{1}{1100}$; and fourth, 200^{m} long, $\frac{1}{884}$; then ascending $1,300^{m}$ long, $\frac{1}{400}$, going into the station upon a plane of 200^{m} long.

3rd. From Hattersheim to Flörsheim, a direct line 6691.79^{m}, having three descents and six ascents.

First descent, 409^{m} long, $\frac{1}{548}$; second, 2,400^{m} long, $\frac{1}{320}$; third, 600^{m} long, $\frac{1}{400}$; then ascending 653^{m} long, $\frac{1}{800}$; second, 515^{m} long, $\frac{1}{346}$; third, 232^{m} long, $\frac{1}{464}$; fourth, 400^{m} long, $\frac{1}{979}$; fifth, 880^{m} long, $\frac{1}{3763}$; and sixth, 1,300^{m} long $\frac{1}{1974}$.

4th. From Flörsheim to Hocheim 6483.71^{m}, having two curves divided with four different radiuses, three descents, two planes, and one ascent.

1st part of	curve	2,341^{m} long,	having a	radius of	3,680^{m}
2nd	„	1,353^{m}	„	„	2,140^{m}
3rd	„	650^{m}	„	„	2,027^{m}
4th	„	624^{m}	„	„	5,714^{m}

First descent 2,100^{m} long, $\frac{1}{1013}$; next a plane of 214^{m} long, and ascending 1,400^{m} $\frac{1}{372}$; another plane of 978^{m} long, followed by the second descent of 790^{m} long, $\frac{1}{400}$; and third 602^{m} long $\frac{1}{646}$, entering Hocheim upon a gentle curve of 624^{m} long, and 5,714^{m} radius, as given above.

5th. From Hocheim to Castel 5073.40^{m}, having two curves, six descents and one ascent. The line has here two descents upon a straight line before entering the first curve. The first descent is 1,153^{m} long, $\frac{1}{400}$; second 400^{m} long $\frac{1}{813}$, entering the first curve of 1,276^{m} long, and 3,300^{m} radius; an ascent of 1,276^{m} long, $\frac{1}{2000}$; and third descent 324^{m} long, $\frac{1}{724}$; fourth, 560^{m} long, $\frac{1}{1111}$; fifth, 509^{m} long, $\frac{1}{663}$; and sixth, 854^{m} long, $\frac{1}{512}$, entering into Castel with the latter descent upon a curve of 768^{m} long, having a radius of 747^{m}.

6th. From Castel to Wiesbaden 8,481^{m}, with six curves, one plane, and one ascent. This is the worst part of the whole railway, as it ascends the whole way into Wiesbaden, leaving the station Castel with a curve and ascent. The station has a length of 200^{m}, being horizontal; the first part of ascent 370^{m} long, $\frac{1}{300}$; the first curve, 370^{m} long, 700^{m} radius, a straight line of 507^{m} ascending $\frac{1}{300}$, then coming into a curve of 930^{m} long, with a radius of 2,500^{m}, this curve being quite horizontal; another straight line of 1,440^{m}, rising $\frac{1}{300}$, joining the third curve, 1,420^{m} long, and 2,000^{m} radius, ascending $\frac{1}{300}$; another straight line of 280^{m}, rising $\frac{1}{300}$, and three curves joining each other; fourth curve, 1,097^{m} long, 2,000^{m} radius; fifth, 840^{m} long, 1,800^{m} radius; and sixth, 700^{m} long and 1,604^{m} radius, entering the station at Wiesbaden with a straight line of 672^{m}, rising $\frac{1}{300}$, the station being 200^{m} long, and quite horizontal.

7th. The Biebrich branch joins the main line half-way between Castel and Wiesbaden, entering it with a curve on the right hand, with a radius of 100^{m}, and on the left with one of 189^{m}. It seldom happens that a locomotive must enter these curves, the first, perhaps, only for a few yards to bring a luggage train, which is brought by horses; and second, through which a locomotive can pass for a similar purpose, or a special train, but which very seldom happens. The other part of the line is straight, with the exception of entering the station, where is a short curve, the station itself being upon a staight line.

CARRIAGES, FARES, AND TRAFFIC.

There are four classes of carriages; the 1st class or Berlins are in three compartments, each holding six persons, similar to those upon the Grand Junction Railway, and other railways in England, fitted out and upholstered with drab-coloured cloth, the seats and backs being stuffed with horse-hair. These carriages are painted a dark green colour intermixed with black, having the arms of Frankfurt, Mainz, and Wiesbaden painted upon their doors. The frame of carriage and wheels are nicely picked out with black and red stripes.

The weight of carriage, with wheels, &c., complete, is 63 cwt., and cost about 3,500 fl., or = £291 13*s.* 4*d.* (See Plate IX.)

2nd class, or diligence, in two compartments, similar to the 1st class carriages upon the Belgian railways, holding in each compartment nine persons; these are fitted out similar to 1st class, with the exception of having no arm-leans, having as well as 1st class, glass windows to shut up and down, and are altogether quite as comfortable, but not quite so select. (See Plate X.)

Each carriage weighs 61½ cwt., and cost complete, with wheels, &c., 2,500 fl., or = £208 6*s.* 8*d.*

3rd class, or Char-a-banc, holding forty persons, are divided into three compartments, each having two doors, the two end compartments holding each ten, and the middle twenty persons; the seats are stuffed, and covered with horse-hair cloth; the sides are closed by curtains. The partition between each compartment is carried up to the roof of the carriage, so that they are also a very warm carriage, and similar to the 2nd class carriages upon the Belgian railways. (See Plate XIII.)

The weight of one carriage, as before, is 66 cwt. and cost 2,160 fl. = £180.

4th class are similar to the 3rd, with the exception of having no partition between compartments, merely an open frame-work, and the seats not being stuffed; the sides are also furnished with curtains, to shelter the passengers from the weather. These carriages have mostly breaks of the common kind. (See Plate XIV.)

Each carriage weighs 61 cwt. and cost 1,960 fl. = £163 6*s.* 8*d.* The 2nd, 3rd, and 4th class carriages are all painted alike, a green colour, the 2nd having one coat of varnish more, the sloping parts of frame-work being picked out black and red, the wheels plain green; the number and class of carriages being painted in legible figures and letters upon both sides.

There are as well as the above several mixed carriages, two of which have 1st and 2nd classes very comfortable; they are generally used in winter when the trains are short; they are in three compartments, holding in all twenty-eight persons, viz., the two ends, being 2nd class, hold each ten, and the middle, 1st class, eight persons. These carriages are equal in appearance and equally as comfortable as the 1st class carriages. (See Plate XI.)

The others are for 2nd, 3rd, and 4th classes; these carriages are generally used for the Biebrich branch, running from thence to Wiesbaden, and vice versâ, and to Castel, and vice versâ; they are similar to the 3rd class, having one end closed in with glass windows and doors for 2nd class passengers, the other end for 3rd class, and the middle for 4th class, the two ends holding each ten and the middle twenty passengers. These carriages are drawn by horses from the main line to Biebrich, they being detached while the train is in movement by a simple piece of machinery. The points being changed after the train has passed on, the carriages run in of themselves, and are brought up with a break at the point required, where horses are awaiting to take them to their destination. (See Plate XII.)

The traffic is a mixed one, but consists mostly of passengers, the trains being intermixed with goods, cattle, and gentlemen's travelling carriages, no horses being carried. The traffic may be best judged of by the returns of the last two years, 1844 and 1845. (See Appendix.)

			FL.	χ		χ	
The price of 1st class	passenger	for 26 miles	2	42	or =	6.2	per mile.
2nd	,,	,,	1	48	or =	4.15	,,
3rd	,,	,,	1	15	or =	2.88	,,
4th	,,	,,	0	51	or =	1.96	,,

Thus the 1st Class = 2.06*d.*, the 2nd 1.38*d.*, the 3rd .96*d.*, and the 4th 6.53*d.* per English mile.

Each passenger is allowed 40 lbs. weight of luggage free, but from 1 to 10 lbs. more for the whole distance 15 χ, or .55 χ per mile, or = 18.5*d.*; from 11 to 20 lbs. 25 χ, or .92 χ per mile, or = .306*d.*; from 21 to 30 lbs. 35 χ, or 1.29 χ per mile, or = .43*d.* For greater quantities the price is somewhat reduced.

The price for transporting a gentleman's travelling carriage for the whole distance is

FL.	χ		χ		
9	12,	or per mile	20.47,	or = 6.8 pence,	for a heavy carriage.
7	0,	,,	15.55,	or = 5.18 ,,	for a light ditto.

	FL.	χ		χ			d.
For an ox per whole distance	1	20,	or	3.07	per mile,	or =	1.02
,, 1 pig ,, ,,	0	36,	,,	1.38	,,	,, =	.44
,, 1 sheep ,, ,,	0	18,	,,	.69	,,	,, =	.23
,, 1 calf ,, ,,	0	24,	,,	.92	,,	,, =	.30
,, 1 dog ,, ,,	0	30,	,,	1.153	,,	,, =	.384

Goods or merchandize are divided into four classes; the 1st is as follows:—grain, fruit, potatoes, meal, fire-wood, coals, pig iron, old metal, and any raw produce, the price of which is for the whole distance 12 χ per cwt., or .46 χ per mile = .153*d.*; a less quantity than 45 cwt. cannot be taken as 1st Class, or must pay 2nd Class tariff.

2nd Class, colonial, drysalters, wine, spirits, beer, oil, cases of mineral water, &c., cotton, wool, hops, leather, silk, cast iron materials, tin, lead, hemp, flax, stone and glass ware, &c., which for the whole distance costs 13 χ, or .5 χ per mile = .166*d.*

3rd Class, is goods, or packages taken as passengers' luggage, and costs for the whole distance 22 χ, or .842 χ per mile = .280*d.*

4th Class, money, or any articles which are by value declared, costs 3 χ, or 1*d.*, per 100 fl. worth, for the whole distance or any distance, no matter how short.

Merchants or expeditors sending per railway in one year

From	12,000 cwt.	to	18,000 cwt.	receive	5	per cent. return.
,,	18,001	,,	24,000	,,	7½	,,
,,	24,001	,,	50,000	,,	10	,,
,,	50,001	,,	100,001	,,	15	,,
,,	100,001	,,	and upwards	,,	20	,,

TABLE, showing number of Passengers travelled on Railway, from the opening to 31st October, 1845.

	1839	1840	1841	1842	1843	1844	1845	REMARKS.
January	Part of railway only being opened, from Frankfurt to Höchst, 26th September, and from Frankfurt to Hattersheim, 24th November.	The whole of railway opened, 13th April.	16,564	24,292	30,155	28,409	30,835	
February			26,234	29,373	34,675	33,316	28,701	
March			37,476	47,025	36,572	49,052	28,916	In this month, 1845, on account of the railway and station at Castel being overflowed with water, the traffic was stopped for eight days. The damage sustained was covered by 3,000 fl. not including the loss of income for that time.
April			59,843	57,744	60,637	60,831	39,818	
May			85,401	83,620	60,275	67,076	64,290	
June			82,606	90,837	78,631	92,882	86,932	
July			111,713	120,366	105,978	101,262	116,609	
August			116,884	111,640	108,990	96,351	107,538	
September			100,920	105,009	101,234	93,722	95,025	
October			56,625	67,285	50,236	52,074	55,340	
November			42,615	39,010	41,218	39,359		The winter being long the number of passengers much reduced from November, 1844, to March, 1845.
December			32,670	32,811	36,059	29,333		
Total	61,766	658,564	769,551	809,012	744,660	743,667		

Total income, from opening to 31st December, 1845.

1839		1840		1841		1842		1843		1844		1845		
FL.	x	FL.	x	FL.	x	FL.	x	FL.	x	FL.	x	FL.	x	
16,464	25	351,947	47	416,980	6	453,555	23	436,567	22	435,373	0	437,032	8	

Total outlay for working, from opening to 31st December, 1844.

1839		1840		1841		1842		1843		1844		REMARKS.
FL.	x	FL.	x	FL.	x	FL.	x	FL.	x	FL.	x	
23,086	57	140,787	29	220,790	50	236,706	25	213,572	40	235,885	35	Not including new locomotives or carriages.

STATIONS AND HOUSES.

STATION AT WIESBADEN, VIEW FROM THE STREET.

The station houses and passenger sheds are very neat buildings, designed by Mr. Oppermann, architect in Mainz, who has shown a great deal of taste in his design, and judgment in the construction. The fault, if any, belongs to the locality, not to the architect. The passengers, in bad weather, have no covering between the waiting rooms and carriages.

The station house in Frankfurt is a large stone building, being a large pavilion with two wings, and at the end of each wing a small pavilion; the large or middle building contains, 1st, on the ground floor, the booking clerks' offices, where the tickets are given out and money taken; 2nd, in first story, the sitting room for Directors, where their meetings are held, and acting Directors' offices, with office for head cashier and secretary. The attics are used as lumber rooms and store rooms for articles which are left behind. The right wing is used as waiting room for 1st, 2nd and 3rd class passengers, being very tastefully fitted out and decorated; sofas, with horse-hair seatings running round the walls, of mahogany; the windows having beautiful chintz curtains, and the roof or ceiling being tastefully decorated. At the end of this wing is a small pavilion two stories high, the ground story being used as offices and storerooms for luggage and goods transport, the upper story as dwelling for foreman and clerk. The left wing is used as waiting room for 4th class passengers, being as large as the other, but quite plain, the seats being of oak. The pavilion at the end is used for steam-boat offices, &c., on ground floor, and the upper story as a dwelling for the stations overseer. (See Plates III., IV., and V.)

The station houses at Castel and Wiesbaden are very similar to the above, with the exception of the Castel station house being built of wood, and having a covered passage, used only in bad weather, between the waiting rooms and carriages, which was recently erected. Mainz and Castel are joined together by a bridge of boats, as shown in Plates XX. and XXI.

The intermediate station houses, at Höchst, Hattersheim. Flörsheim, and Biebrich, being merely large enough for the clerks to live in the upper stories, the under parts or ground floor being used as waiting room and clerks' office. The station house at Hocheim is considerably smaller, being only a cottage, containing waiting room and office, with a small sleeping room for watchman or police.

The passenger sheds are all splendid buildings, being three in number upon the main line and one at Biebrich, of wood; but from their neat construction and decoration, deceive the eye at once into believing they are made of more solid and substantial materials[a]. (See Plates VI., VII., and VIII.)

ELECTRIC TELEGRAPH.

The electric telegraph, which is now completed between Castel, Biebrich, and Wiesbaden, is constructed on a very simple and economical plan, the cost being only £11 per mile.

The above-mentioned three stations are included in the line, and each of them is every moment at liberty to forward intelligence to the other two. The despatches are given by a pointer moving on the centre of a dial plate, round which the letters of the alphabet are marked.

Lately a peculiar mechanism has been adopted by the inventor, Mr. William Fardelly, by which the pointers of the several telegraphs are made to move with great speed and ease, so that a small battery of two or three elements is sufficient to move several of these instruments. There is likewise a portable telegraph, to be carried with the trains; this instrument can be applied to any part of the circuit whatever: nevertheless, preparations are being made for this purpose at given distances along the line. The whole is worked by a single conducting wire of copper, 1½ millimetre thick, supported by wooden posts, into the tops of which the wire is fixed by a wooden peg or wedge.

There is also a printing apparatus worked by the same single wire, which may be placed at each station; but as simplicity seems the desirable point for railroads, these apparatuses are better adapted for communication between two end stations alone.

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[a] The intermediate stations, Höchst, Hattersheim, and Hocheim, have siding places, Hattersheim being the middle station where the trains meet, they starting at equal times from Castel and Frankfurt.

This system, which answers all the purposes of the railway, is in continuation throughout the whole line from Frankfurt to Wiesbaden.

LOCOMOTIVE ENGINES.

Are twelve in number, all six-wheel engines, from the following manufactories: —Nos. 1 to 6, from Messrs. Robert Stephenson and Co.'s, of Newcastle-on-Tyne, having 12 inc. cylinders and 18 inc. stroke, the middle or driving wheels 6 ft. diameter, and bearing wheels 4 ft.; Nos. 7 and 8 from the same establishment, having 13 inc. cylinders and 18 inc. stroke, driving wheels 5½ feet, and bearing ditto 3 ft. 9 inc. diameter; No. 9 from Messrs. Jacobi, Haniel, Hyson, and Co., of the gute Hoffnungs Hütte, near Sterkrath, on the Ruhr; the cylinders are 12 inc. diameter and 18 inc. stroke, driving wheels 6 ft., and bearing ditto 4 feet diameter; Nos. 10 and 11 from Messrs. Sharp, Roberts, and Co., of Manchester, having 14 inc. cylinders and 18 inc. stroke, the driving wheels 5½ ft., and bearing ditto 3½ ft. diameter; No. 12 from the house of Cockerill, in Seraing, with 14 inc. cylinders and 22 inc. stroke, the driving wheels 5½ ft., and bearing ditto 3 ft. 9 inc. diameter. This engine is constructed after Mr. Robert Stephenson's new patent, with long boiler and expansion, giving great satisfaction as regards economy in fuel. The above-mentioned locomotives were furnished between 1839 and 1841. These locomotives were furnished with spark catchers, and extra blast pipes, as the quality of the coke varies so much; the main pipe must be kept small enough to suit the inferior; the diameter of main pipe at its outer end is from 2⅝ inc. to 2⅞ inc., the other being 3 inc., most of which are as shown in Plate XVIII.

Accidents upon railways are of very frequent occurrence, arising from various causes, and are attended with various amounts of damage, not unfrequently causing serious losses of life as well as property; it therefore behoves every railway company to offer to the public as much security as possible, which in a great many cases can be done at a very trifling outlay. It very often happens, that could the locomotive and tender be detached from the train when running, very serious accidents would have been avoided.

Upon the Taunus Railway an apparatus is in use, which from its simplicity and efficiency cannot easily be excelled; it is attached to the hinder part of the tender, and is used in case of emergency, as well as being constantly used when at the stations, where it is necessary to uncouple the engine and tender from the train, thereby saving great trouble, and with less danger to engine-men and firemen, as they can disconnect at any speed or at any time, whether the engine and train is in motion or not.

The apparatus is shown in Figs. 1 and 2, Plate XIX., and consists of a lever, A, about 5 to 6 feet long, attached to a weigh-bar, B, which rests upon the upper part of tender, and moves in the carriages, K K. Upon the end of weigh-bar, B, is keyed a short lever, or arm, C, which is connected with a double eye and rod to the slightly conical pin, D, going through the large double eye, *d*, which is attached to the drag-spring of tender, F. The links, E E, are to admit of the vibration of drag-spring, which is always more or less stretched when the train is behind the tender; G is a guide bolted upon the planking of tender to keep the pin D always in a right position; H is a standard or catch-plate screwed upon the tank, to hold the lever A in its place when the train is coupled to the tender.

When it is found necessary to uncouple, the lever A is lifted out of the notch of the plate H, and allowed to fall, whereby the pin D is raised; the coupling between carriage and tender will immediately fall of itself.

This apparatus is also used upon some carriages which run into a branch line, the carriage being uncoupled at the time the train is running, some time before arriving at the switches or points leading into the branch, whereupon the train passing they are changed, the carriages run in of themselves, and are brought up with a break at the required spot, where horses are awaiting to take them to their destination.

Fig. 3 is a front view of rod and pin, D.

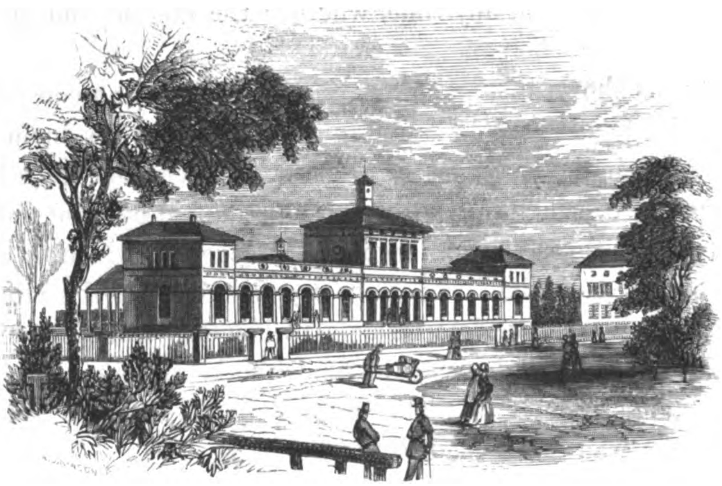
Fig. 4 is a front view of catch-plate, H.

Fig. 5 is a view of the part of guide, G, which is bolted to the planking.

Fig. 6 is a ground plan of ditto.

This system has now stood the test of six years, answering all the purposes for which it was intended, and has very frequently been of the utmost service, more particularly by the bursting of a tube in the boiler, where the flames have been driven from under the fire-bars of fire-box, and through underneath the tender, to such an extent, that had the engine and tender not immediately been detached from train, there was every possibility of setting the first carriage on fire.

The apparatus can be easily adapted to any form of tender or carriage at pleasure, taking care that the links, E E, are kept long enough to admit of the vibration of drag-spring.



STATION AT FRANKFURT-ON-MAINE, VIEW FROM THE PROMENADE.

ESTABLISHMENT

Consists of, 1st, a board of Directors, or Verwaltungsrath, chosen by a general meeting of the shareholders, and consists of six members, two being chosen from Frankfurt, two from Mainz, and two from the shareholders of Wiesbaden, their meetings generally being held in Frankfurt. Out of the six members are chosen a chairman and vice-chairman; a secretary as well always attending to note minutes of meetings.

2nd. Technical administration, consists of a resident Director and Inspector, the Director having full control and management of traffic, &c.; the Inspector having the inspection of railway, and all buildings, and every thing moveable upon the whole establishment, these two gentlemen always being present at the meeting of the board, every other officer being under their especial order and control.

The establishment in Frankfurt is as follows:—head cashier, or clerk, director's secretary, reviser, stations manager, 1st and 2nd ticket clerks, two merchandize expeditors and two helpers, one stations overseer, with two porters and ten men of different grades.

In Höchst, one ticket clerk, one overseer, and one porter; in Hattersheim, a stations manager and ticket clerk, one overseer, one porter, two waggon greasers, and four water pumpers; Flörsheim, one ticket clerk, and one porter; Hocheim, one ticket clerk, and one porter.

In Castel, a stations manager, 1st and 2nd ticket clerk, one merchandize expeditor, one overseer, two porters, and twelve men of different grades.

Biebrich, one stations manager and ticket clerk, one overseer, one porter, and three men of different grades.

Wiesbaden, a stations manager, 1st and 2nd ticket clerks, one merchandize expeditor, one overseer, two porters, and seven men of different grades.

With the trains the following persons are employed:—1st, the Frankfurt train, one commissioner, (Zug commissair,) one head conducteur, and four guards, one packmaster, and two breaksmen; 2nd, Wiesbaden train, one commissioner, one head conducteur, four guards, one packmaster, two breaksmen, and two guards for the Biebrich branch; all the above being under the control of Director.

The way establishment is under the control of inspector, having one head overseer, five under overseers, and seventy-one men, acting as police, switch-changers, and plate-layers.

Locomotive and repairing establishment, also under the control of inspector, consists of locomotive superintendent, one foreman at Frankfurt station, six engine drivers, ten stokers, and five cleaners; and in the workshops one foreman, one clerk, fifty-four workmen, one general storekeeper, and two labourers.

Thus altogether there are 260 persons employed and receiving salaries, besides day labourers for repairing railway, whose wages amounted in 1844 to £820 7*s.* 8*d.*

GENERAL OBSERVATIONS.

All reports sent to the board of Directors must go through the hands of the resident[a] Director or Inspector, and by him laid before the committee when sitting, which takes place twice a month generally. The locomotive superintendent must send in a report once a month, of repairs, accounting for all work done to locomotives, tenders, carriages, &c., as well as all other repairs, accounting for all materials expended. For other departments the month is divided into three periods, when all returns are made, of cokes, oil, materials, passengers, goods, and money, &c.

In the summer months there are generally four locomotives in fire every day, there being six through trains from each end, besides extra to Wiesbaden from Castel, two locomotives doing the duty the whole day, the others standing in reserve, and running the extra trips; thus each engine on active duty runs upwards of 156 miles per day, which it does three to four days per week; it is then taken into the shed and examined, and remains as many days before again being taken out. In winter there are only four through trains per day, and three locomotives in fire, the one for doing the extra trip and reserve, the others for the regular duty. Each engine driver and fireman have their own engines, and only travel with them, therefore each engine-man rests as many days as his engine, or at least his duty is not so arduous, having only to see that all is in proper order. The general average speed of trains is from 20 to 25 miles per hour; should the engine drivers exceed that, they are liable to be fined by the Company. To this slow speed is to be adduced the very few accidents which have occurred upon this line since the opening.

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[a] The resident Director is Mr. A. Beil, of Frankfurt, and the Inspector is Captain Otto Mellar, of the Royal Prussian Engineers, of Mainz.

The trains are in summer generally very heavy, averaging from 16 to 18 carriages and trucks, but on Sundays and holidays from 20 to 30. On some days in summer there are from 12,000 to 13,000 passengers travelling in one day; in winter the trains average from 10 to 12 carriages and trucks. The number of passengers travelled upon the railway in 1844, divided by 365, yields an average of 2037.4 persons per day; and in 1845 gives an average of 2020.8 passengers per day.

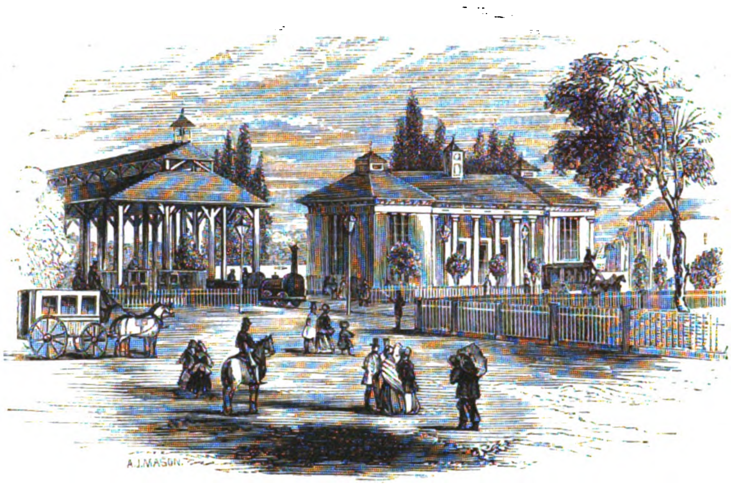
Labour is rather cheap, but materials are high; a good blacksmith does not receive more than 2*s.* 2*d.* per day, a mechanic 1*s.* 8*d.* to 2*s.* per day, joiners the same, day labourers 1*s.* to 1*s.* 2*d.* per day, all working much longer hours than are generally worked in England.

Brass, copper, iron, and metal, are about 20 to 30 per cent. dearer here than in England; coke costs 33*s.* 4*d.* per ton, and is about 20 to 30 per cent. inferior to English.

WORKSHOPS, ETC.

The workshops in Castel being the principal one, sall the heavy work is done there, and general repairs. The machinery consists of one large lathe for turning driving and other wheels for locomotives; one 14-inch screw-cutting and turning ditto; one 12-inch self-acting ditto, for turning axles, &c.; one 10-inch ditto common, for turning bolts, nuts, &c., and short work; one ditto for turning carriage and tender wheels turning upon their own bearings; one small planing machine; one small drilling ditto; one screwing ditto, and one grindstone, all of which are driven by a steam-engine of eight horses power. One of Shank's punching machines, and cylinder boring machine, for boring in their places, has also of late been added to the list, being two of the most useful machines in existence, more especially the latter.

In Frankfurt there is only one small hand-lathe, there being only five to six workmen employed there on account of the carriage repairs.



STATION AT CASTEL, OPPOSITE MAINZ, FRONT VIEW

DESCRIPTION OF DRAWINGS.

Numbered

I. and II. Sectional double plate, showing length and gradients, the tints determining each State.
III. Front elevation of the Frankfurt station house.
IV. Sectional elevation of ditto.
V. Ground plan of ditto, bottom flat, and upper story. } Engraved on one Plate.
VI. End view of passenger sheds.
VII. Side view of ditto, and sectional elevation } Engraved on one Plate.
VIII. Section of ditto.
IX. Elevation, end view, cross section, and plan of 1st class carriages.
X. Ditto ditto ditto ditto of 2nd „ „
XI. Ditto ditto ditto ditto of mixed 1st and 2nd classes.
XII. Ditto ditto ditto ditto for the Biebrich branch line, showing the break and apparatus for uncoupling the carriage when in motion.

PLATE.

XIII. Elevation and sectional elevation of 3rd class carriages.

XIV. Elevation, end view, cross section, and plan of 4th class carriages.

XV. Details showing different parts of carriages, answering for all classes, with exception of 1st class.

- Fig. 1. Showing the manner the buffer springs are coupled with buffers, with buffer boxes, drag hook, and cast-iron frames, A A.
- „ 2. Elevation, plan, and end view of malleable iron axle horns, for holding grease boxes, drawn 1 inc. per foot.
- „ 3. Iron eye-bolt for receiving the spring carriers, with bolts and nuts for screwing the horns on to cross sheaths of carriages.
- „ 4. Carriers for bearing springs.
- „ 5. Shows section of middle seats of 3rd class carriages.
- „ 6. Showing section of drag hook and spindle for buffer spring.

XVI. Details of different parts, answering for all carriages, with exception of 1st class.

- Fig. 7. Carriage wheels and axles for all carriages and trucks, with exception of 1st class, there being a little difference in their lengths.
- „ 8. Represents the bearing springs, 3 inc. broad, containing 11 plates, being 4 inc. deep for 2nd class and the mixed 1st and 2nd class carriages, and 13 plates 4½ inc. deep for 3rd and 4th classes, scale 1½ inc. per foot.
- „ 9. Is the front view of the two straps, *d*, which join the bearing springs and grease boxes together.
- „ 10. A thin plate which comes between the bolt-heads and cross sheaths, on being bolted to the axle-horns.
- „ 11. Stretcher which joins the two axle-horns together, helping to stiffen them.
- „ 12. A small cod or carriage of cast iron, which is screwed upon the roof of all carriages for hand-rail.
- „ 13. A cast iron pillar for supporting the seats in the 3rd and 4th class carriages.

PLATE.

XVII. Details of different parts, answering for 2nd, 3rd and 4th, and mixed carriages.

Fig. 14. Represents a side view and plan of grease boxes.
„ 15. Represents a section and end view of ditto.
„ 16. „ an elevational section of grease boxes.
„ 17. „ ditto ditto and plan of keep for ditto.
„ 18. Represents the brass bearings for ditto.
„ 19 and 20 „ the covers to grease boxes, of sheet iron.
„ 21. Buffer spring frames, of cast iron.
„ 22. Buffer drawn half size.
„ 23. The hinder or back seats of 3rd class carriages.

XVIII. Represents in two figures the spark-catching chimney, with double blast-pipe, as now used.

Fig. 1. Is a section; the inner chimney, A, is 11 inc. diameter, being bell-mouthed at the top, and going 8 to 10 inc. deep into the smoke-box at bottom; the outer case, C C, is surmounted at the top by a brass or copper crown, D D, which has at the outlet at the top an iron tube going 3 to 4 inc. into the interior of crown, the same diameter as small chimney.

The outer case or chimney, C C, is fastened to the smoke-box by means of the cast iron ring or base, E E; on each side is a hand-hole closed by a door, *h h*, for cleaning away the ashes which are deposited. F F are the blast-pipes, which are joined together at the bottom by an elbow pipe of cast brass, in the interior of which is a throttle valve, having a spindle attached to it going through one side of smoke-box, a lever and rod being attached; it is carried up to platform of engine, where it is regulated by engine driver at will.

XIX. Uncoupling apparatus. For description see page 15.

XX. Is the ground plan of bridge of boats crossing the Rhein between Mainz and Castel, showing the timbers and method of joining together. The bridge is 1836 feet long, and is built in Yokes (Iochs) of four boats each, which at certain places can be removed at will. At the Mainz end there is one boat built larger than the others, on account of its having

PLATE.

a platform resting entirely on itself. This boat is always dropped down the stream and pulled to one side when any ships or steamers have to pass through. It is brought up to its place again by means of a winch which stands on board, the cable being fastened to its roller or drum; at this place there is never more than one boat removed, but in the middle where the large rafts (flösze) of timber pass, there are from four to eight taken away, as the case may be. Each boat has an anchor, and secured thereto by a chain cable. The ends or platforms at the ends of bridge resting on the shores, are raised or lowered by powerful screws, to suit the rising or falling of river.

XXI. Details of the preceding.

Fig. 1. Shows a cross section of end or outside boats, and longitudinal section of bridge.

„ 2. Is a cross section of bridge, showing part of the longitudinal section of end or outside boats and cross-timbers.

„ 3. Longitudinal section of bridge, and cross section of middle or intervening boats.

„ 4, 5, and 6. Show cross section of bridge and joinings of timbers, where resting on the intervening or middle boats, and other details.

XXII. to XXV.
Station at Höchst, view from the Railway.
Station at Wiesbaden, view from the Street.
Station at Frankfurt-on-Maine, view from the Promenade.
Station at Castel opposite Mainz, front view.

Castel, Jan. 1846.

ROBERT THORMAN.

APPENDIX,

SHOWING INCOME AND OUTLAY PRO 1844, AND INCOME PRO 1845.

INCOME FOR THE YEAR ENDING 31ST DECEMBER, 1844.

		FL.	χ		£	s.	d.
742,331	passengers	381,793	29	or =	31,816	2	5⅔
11,840½	cwt. passengers' luggage overweight	18,402	53	or =	1,533	11	5⅔
60,211	ditto of merchandize	17,174	33	or =	1,431	4	3
1,248	gentlemen's travelling carriages	8,955	1	or =	746	5	0⅓
4,800	head of cattle	3,433	45	or =	286	2	11
32	ditto of venison	1,130	13	or =	94	3	8⅓
2539	dogs						
13,958	marketings						
1,336	post passengers	2,119	41	or =	176	12	9⅔
177⅒	cwt. of post passengers' luggage overweight						
3,042½	ditto ditto goods						
For extra or special trains		382	45	or =	31	17	11
Passengers paid on the route for higher classes		84	45	or =	7	1	3
Letting grass, clover, &c.		1,555	55	or =	129	13	2⅓
Letting premises at stations, &c.		340	0	or =	28	6	8
	Total	Fl. 435,373	0	or =	£36,281	1	8

The above income divides itself into 12 months as follows:—

	FL.	χ		£	s.	d.
January	14,535	2	or =	1,211	5	0⅔
February	17,370	9	or =	1,447	10	3
March	26,912	57	or =	2,242	14	11
April	35,978	17	or =	2,998	3	9⅔
May	36,117	30	or =	3,009	15	10
June	47,871	6	or =	3,989	5	2
Carried forward	Fl. 178,785	1	or =	14,898	5	0⅓

	FL.	χ		£	s.	d.
Brought forward	178,785	1	or =	14,898	15	0⅓
July	59,412	33	or =	4,951	0	11
August	62,066	20	or =	5,172	3	10⅔
September	60,038	42	or =	5,003	4	6
October	32,937	40	or =	2,744	16	1⅓
November	21,053	20	or =	1,754	8	10⅔
December	16,596	18	or =	1,383	0	6
Extra or special trains	382	45	or =	31	17	11
Passengers paying higher classes	45	48	or =	7	1	3
Post, for passengers, goods, &c.	2,119	41	or =	176	12	9⅔
Letting premises, grass, clover, &c.	1,895	55	or =	157	19	10⅓
Total [*]	Fl. 435,373	00	or =	£36,281	1	8

Expenditure for the Year ending December 31st, 1844.

	FL.	χ		£	s.	d.
Repairs of locomotives and tenders	10,510	52	or =	875	18	1⅓
Ditto of carriages	4,500	30	or =	375	0	10
Cokes	45,912	22	or =	3,826	0	7⅓
Oil, tallow, hemp, &c.	3,002	24	or =	250	4	0
Mechanics' wages	24,425	55	or =	2,035	9	10⅓
Salaries and premiums	86,412	35	or =	7,201	0	11⅔
Rents and taxes	10,107	17	or =	842	5	5⅔
Repairs of station houses	5,386	30	or =	448	17	6
Office expenses	3,957	33	or =	329	15	11
Clothing	3,060	36	or =	255	1	0
Repairs of ballast waggons, &c.	815	21	or =	67	18	11
Wages for repairing railway	9,844	36	or =	820	7	8
Materials for ditto ditto	1,696	3	or =	141	6	9
Divers expenses, including decoration of station at Wiesbaden, to welcome the return of the Duke and his bride, printing, and new electric telegraph between Castel, Biebrich, and Wiesbaden, of about 900 fl.	5,042	25	or =	420	4	0⅓
Heating and lighting stations, &c.	4,561	0	or =	380	1	8
Repairs of moveables, &c.	928	17	or =	77	7	1⅔
Interest	14,586	18	or =	1,215	10	6
Fire assurance	722	55	or =	60	4	10⅓
Seeds and cultivation of slopes, embankments, &c.	412	6	or =	34	6	10
Total expenditure	Fl. 235,885	35	or =	£19,657	2	7⅔

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[*] The nett income of traffic is Fl. 431,272 39χ or = £35,939 7*s.* 9*d.*

		FL.	χ		£	s.	d.
Total income		435,373	0	or =	36,281	1	8
Ditto outlay		235,885	35	or =	19,657	2	7⅔
Nett profit	Fl.	199,487	25	or =	£16,623	19	0⅓

Nett profits divided into five different heads, as follows:—

		FL.	χ		£	s.	d.
1st. Dividend on 12,000 shares at 15 fl. each		180,000	0	or =	15,000	0	0
2nd. Tantieme for resident Director		1,500	0	or =	125	0	0
3rd. Given to fund for pensions, widows, &c.		1,500	0	or =	125	0	0
4th. To be laid to capital reserve fund		6,000	0	or =	500	0	0
5th. To locomotive and transport ditto		10,487	25	or =	873	19	0⅓
Total	Fl.	199,487	25	or =	£16,623	19	0⅓

	FL.	χ		£	s.	d.
The capital reserve fund pro 1844 amounts to	67,000	0	or =	5,583	6	8
Locomotive and transport ditto	24,809	30	or =	2,067	9	2

INCOME FROM TRAFFIC PRO 1845.

			FL.	χ		£	s.	d.
737,590	passengers		378,675	49	or =	31,556	6	4⅓
12,187¾	cwts. passengers' luggage overweight		19,770	12	or =	1,647	10	4
103,452¼	cwts. merchandize		23,371	56	or =	1,947	13	2⅔
1,339	gentlemen's travelling carriages, &c.		9,808	17	or =	817	7	1⅔
4,444	head of cattle, &c.		3,277	42	or =	273	2	10
38 2,314 15,589	ditto venison dogs marketings		1,223	36	or =	101	19	4
For extra or special trains			770	0	or =	64	3	4
Sundries			134	36	or =	11	4	4
Total income of traffic		Fl.	437,032	8	or =	£36,419	6	10⅔

The above income divides itself into 12 months, as follows :—

	FL.	χ		£	s.	d.
January	15,480	45	or =	1,290	1	3
February	15,082	44	or =	1,256	17	10⅔
March	17,337	55	or =	1,444	16	6⅓
April	22,856	27	or =	1,904	14	1
May	36,520	8	or =	3,043	6	10⅔
June	47,756	1	or =	3,979	13	4⅓
July	67,853	14	or =	5,654	8	8⅔
August	71,043	41	or =	5,920	6	1⅔
September	64,017	2	or =	5,334	15	0⅔
October	34,946	11	or =	2,912	3	7⅔
November	23,869	32	or =	1,989	2	6⅔
December	19,363	52	or =	1,613	13	1⅓
Special trains, &c.	904	36	or =	75	7	8
Total .	Fl. 437,032	8	or =	£36,419	6	10⅔
Total income of traffic pro 1844	431,272	39	or =	35,939	7	9
Increase in traffic in 1845 over 1844	Fl. 5,759	29	or =	£ 479	19	1⅔

Castel, January, 1846.

ROBERT THORMAN.

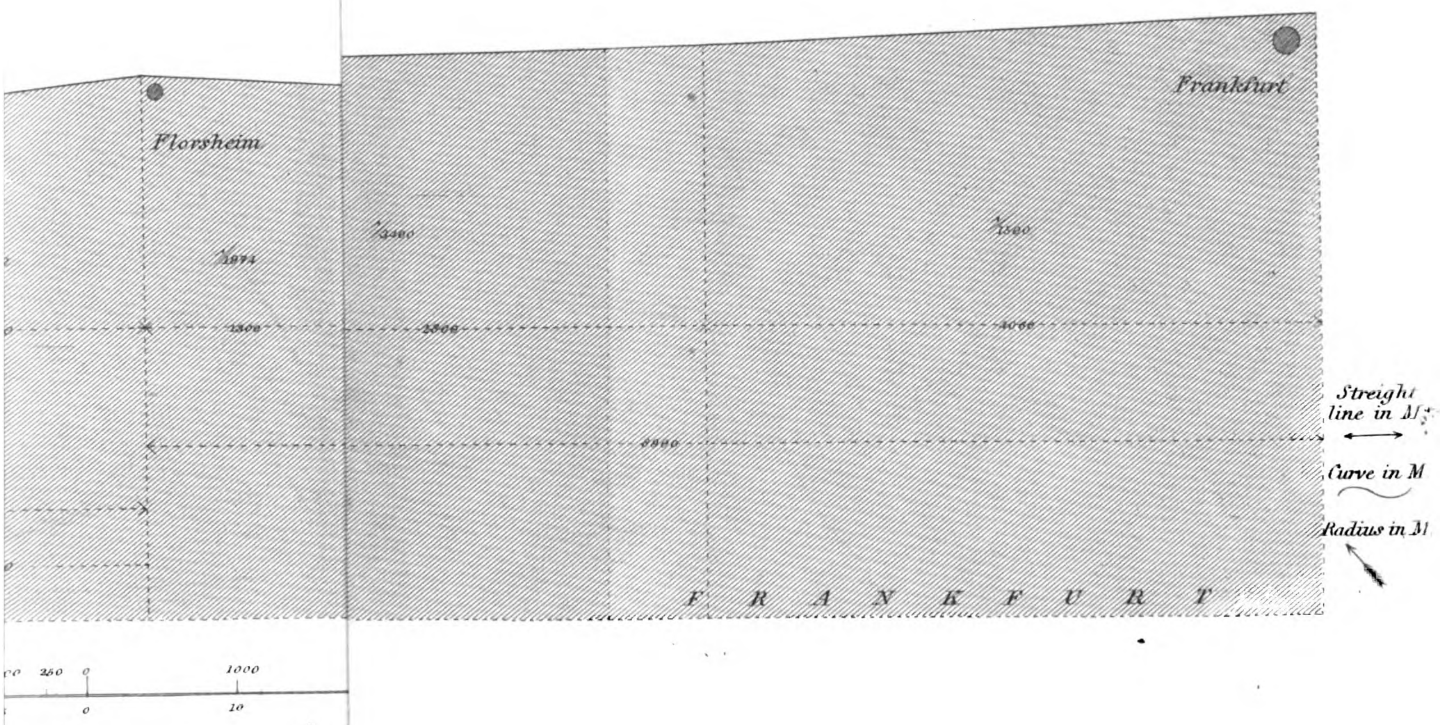
TABLE showing the Total Cost of Mileage of Locomotives upon the TAUNUS RAILWAY in 1844, taken from the Superintendent's Books.

No.	NAME.	Cost of repairs.				Engine driver, firemen, and cleaners' wages, &c.		Greasing and packing materials with fuel.					Total cost.		Distance run in.		Cost per kilometre.	Cost per English mile.	REMARKS.
		Materials.		Wages.				Greasing and packing.		Cleaning materials.		Cokes.			Kilometres.	English miles.			
		FL.	x	FL.	x	FL.	x	FL.	x	FL.	x	FL.	FL.	x			x	x	
1	Blitz	304	32	254	27½	350	27	132	17	48	45	1,793	2,882	28	5,293,854	3290.15	32.67	52.57	
2	Pfeil	1,862	9	1,010	53½	684	14	147	24	37	59	2,126	5,868	39	19,364,986	6441.33	33.78	54.66	Underwent a thorough repair, receiving new fire and smoke box, &c., and set of new iron tubes, partly accounted for in last year's account.
3	Adler	732	35	90	52	1,314	39	359	37	105	53	4,601	7,204	36	19,859,338	12342.66	21.77	35.02	
4	Wiesbaden	2,149	3½	375	47	1,266	7	365	42	85	2	4,724	8,965	41	19,126,048	11886.85	28.12	45.26	Underwent a thorough repair, receiving a new fire-box and brass tubes, part of materials being in last year's account.
5	R. Stephenson...	2,332	59	1,192	17½	429	53	124	20	28	20	1,385	5,492	49	6,493,906	4035.99	51.	81.65	Underwent a thorough repair, receiving new fire and smoke box, &c., and new brass tubes.
6	Gutenberg	348	43	142	21½	1,230	27	330	40	113	40	4,455	6,620	51	18,585,584	11551.00	21.37	34.48	
7	Frankfurt.........	3061	...	1,322	40½	556	2	123	17	46	28	1,987	7,096	28	8,399,390	5220.24	50.69	81.25	Underwent a thorough repair, receiving a new fire and smoke box, and set of iron tubes.
8	Mainz	798	22	354	40	1,037	55	347	10	74	24	4,400	7,012	31	15,641,992	9721.56	26.90	43.28	
9	Rhein	154	52	278	45	342	45	150	19	90	57	1,860	2,877	38	5,177,468	3217.83	33.35	53.64	
10	Main	354	46½	292	1	1,425	17	180	4	117	25	4,549	6,918	33	21,530,078	13381.02	19.28	31.02	
11	Taunus	710	41½	394	34½	1,639	50	296	37	95	10	4,994	8,130	53	24,771,148	15395.37	20.10	32.34	
12	Cockerill.........	175	16	215	47	507	8	133	20	27	55	1,561	2,620	26	7,660,868	4761.26	20.52	33.03	
	Hassia	......	...	......	...	132	58	......	...	...	...	480	612	58	2,021,356	1256.28	18.19	29.27	This engine was upon trial, belonging to the Darmstadt Railway, was a patent invention of and built by Tayleure & Co., Warrington.
	Total	12,984	59½	5,925	7	10,917	42	2,690	7	871	58	38,915	72,304	31	164,926,016	102501.54			

NOTE.—The duplicates, which were taken out of store, are accounted for in this Table, the old materials always being deducted, which will account for the difference between this and the Committee's Report. The Coke burnt by the Locomotives when in reserve is not accounted for in this Table.

Plate I & II

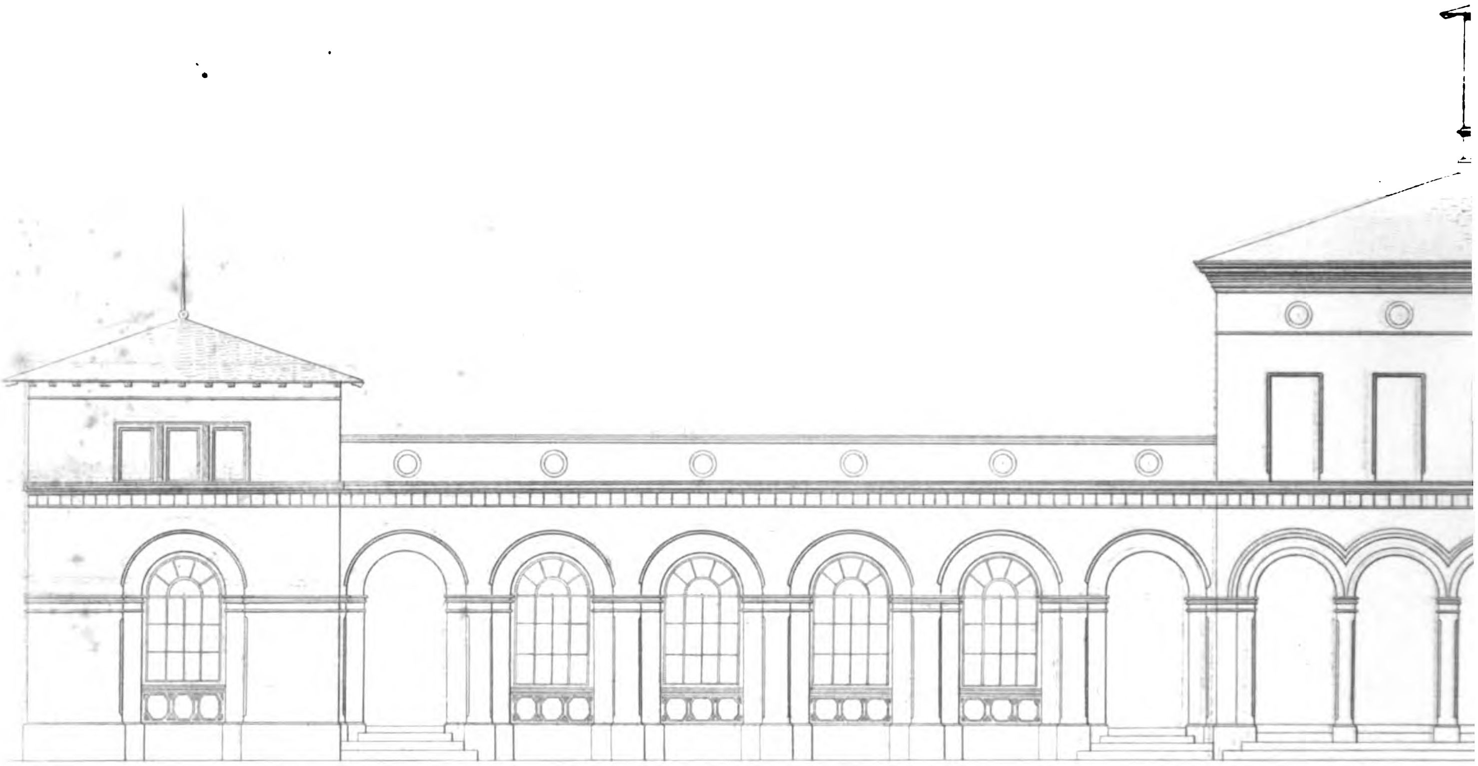
LEVEL

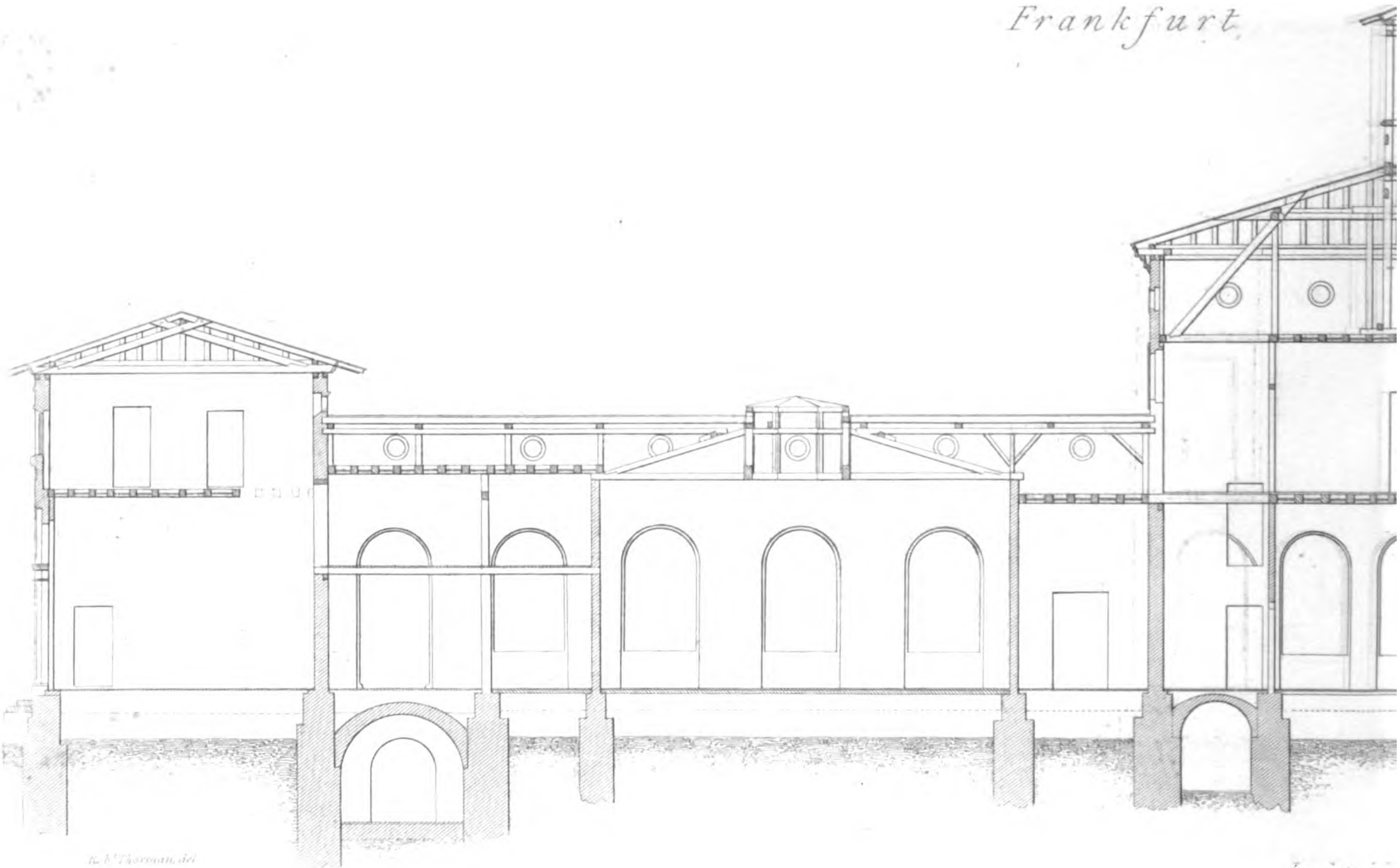


London,

G Winter, sculp^t

FRANKFURT & W

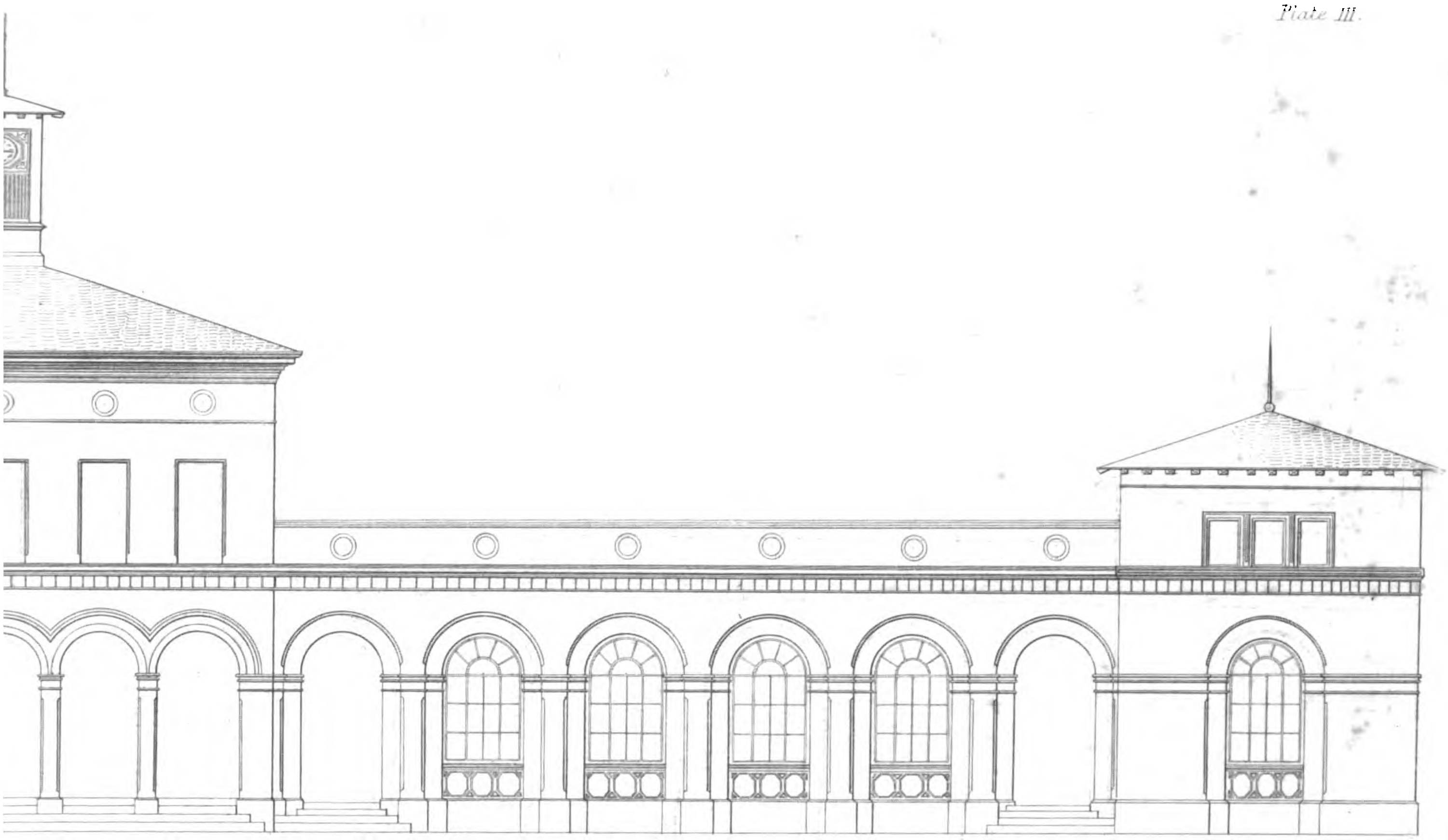




K. v. Thermann del.

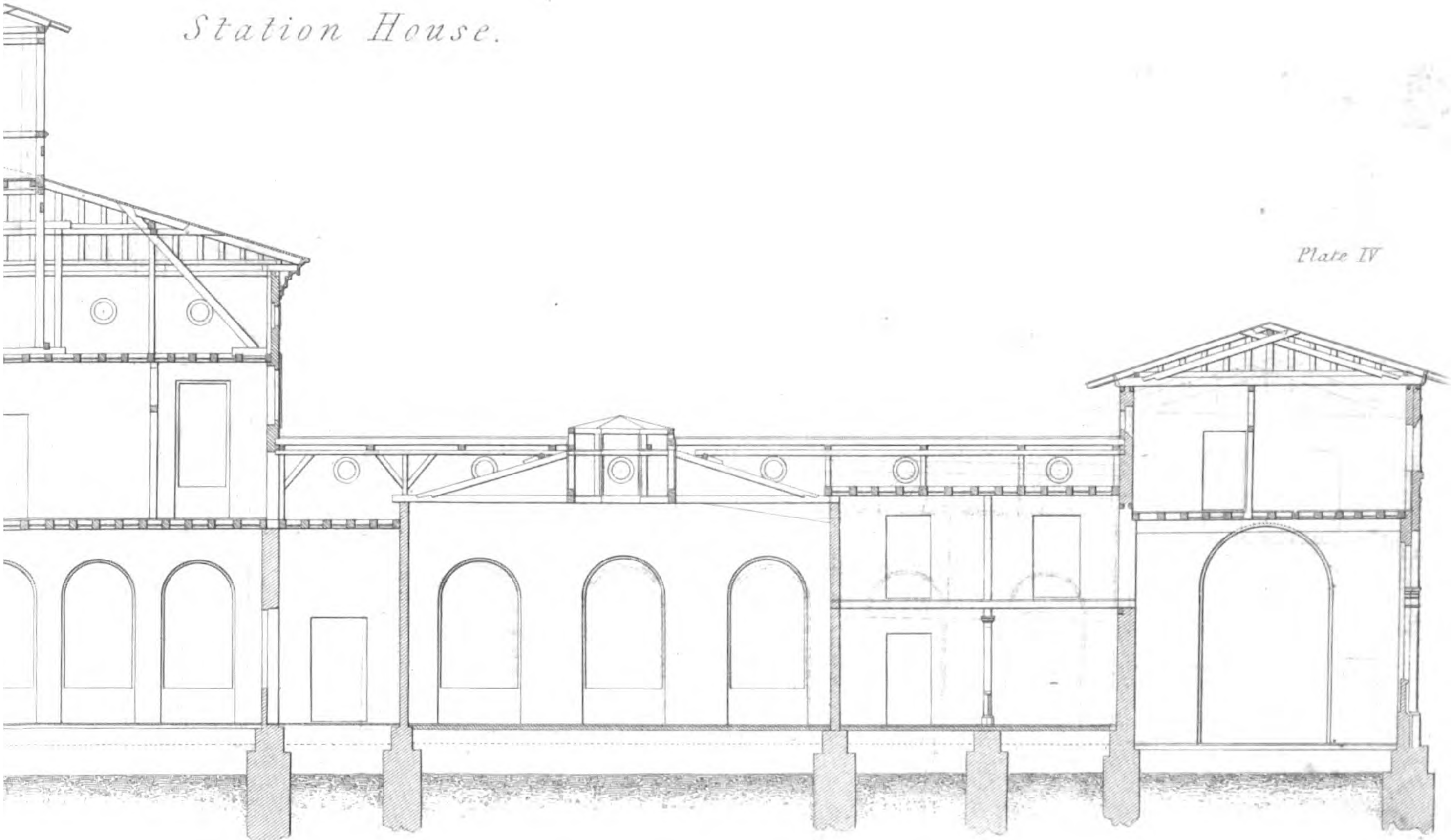
SBADEN RAILWAY.

Plate III.



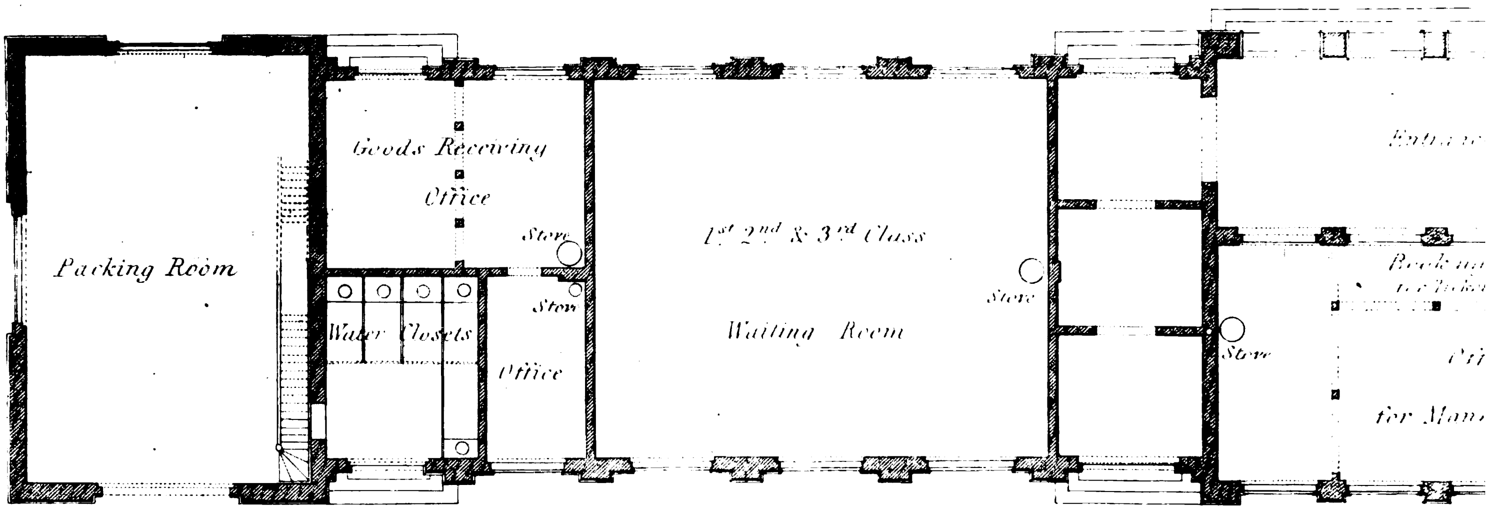
Station House.

Plate IV.

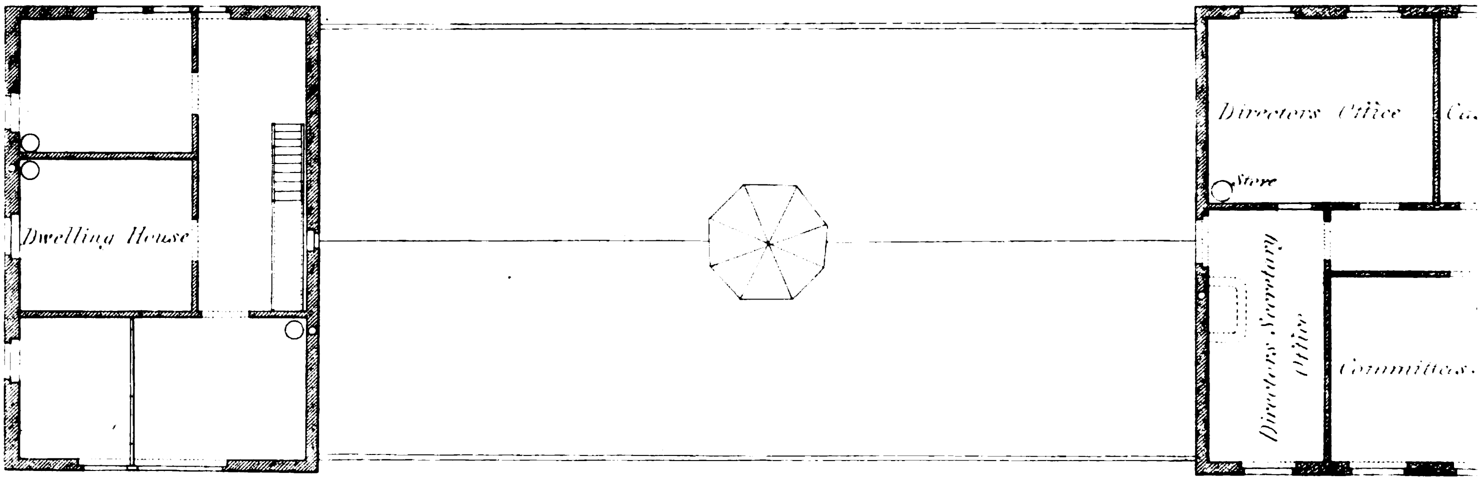


FRANKFURT & WIES

Ground Plan of bottom Flat



Plan of First Storey

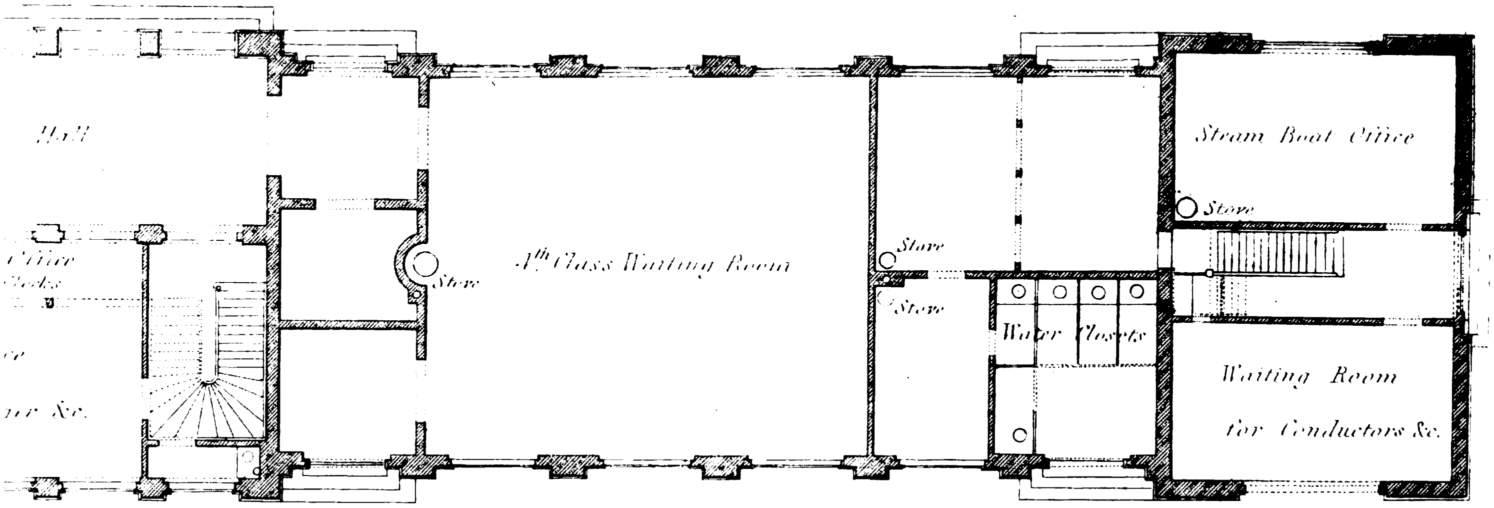


London

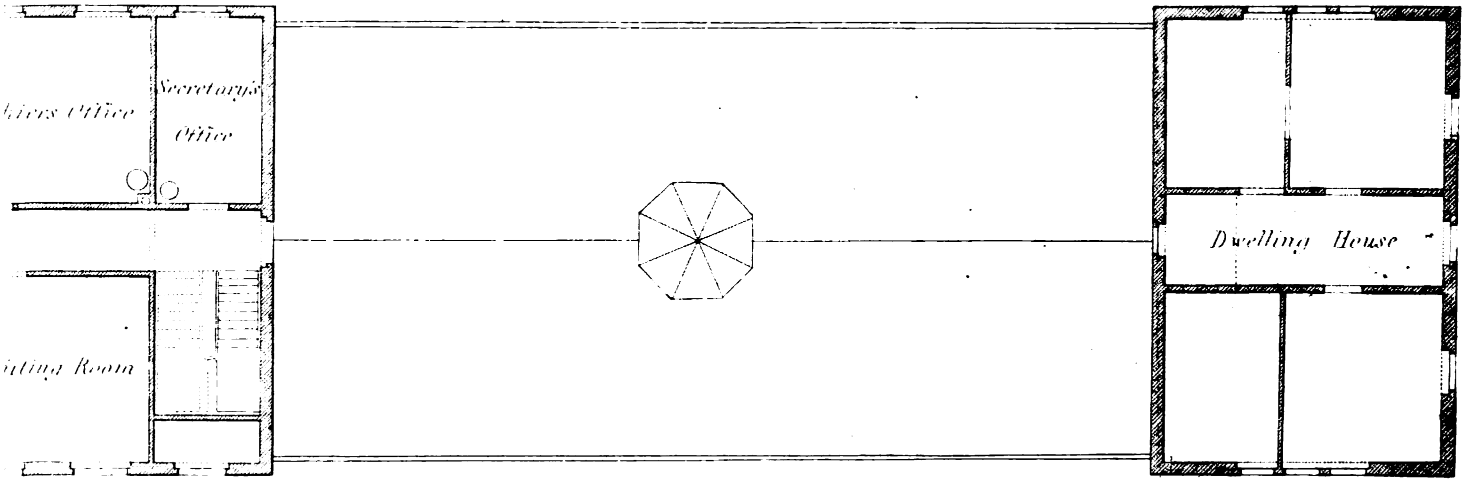
BADEN RAILWAY.

Plate V

' Station House in Frankfurt.



of Station House.



Geo. Winter sc

FRANKFURT & WI

End View of

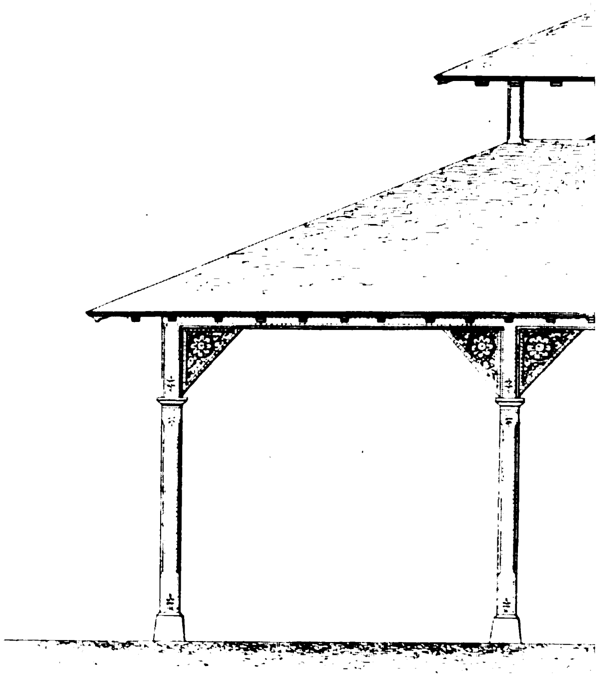
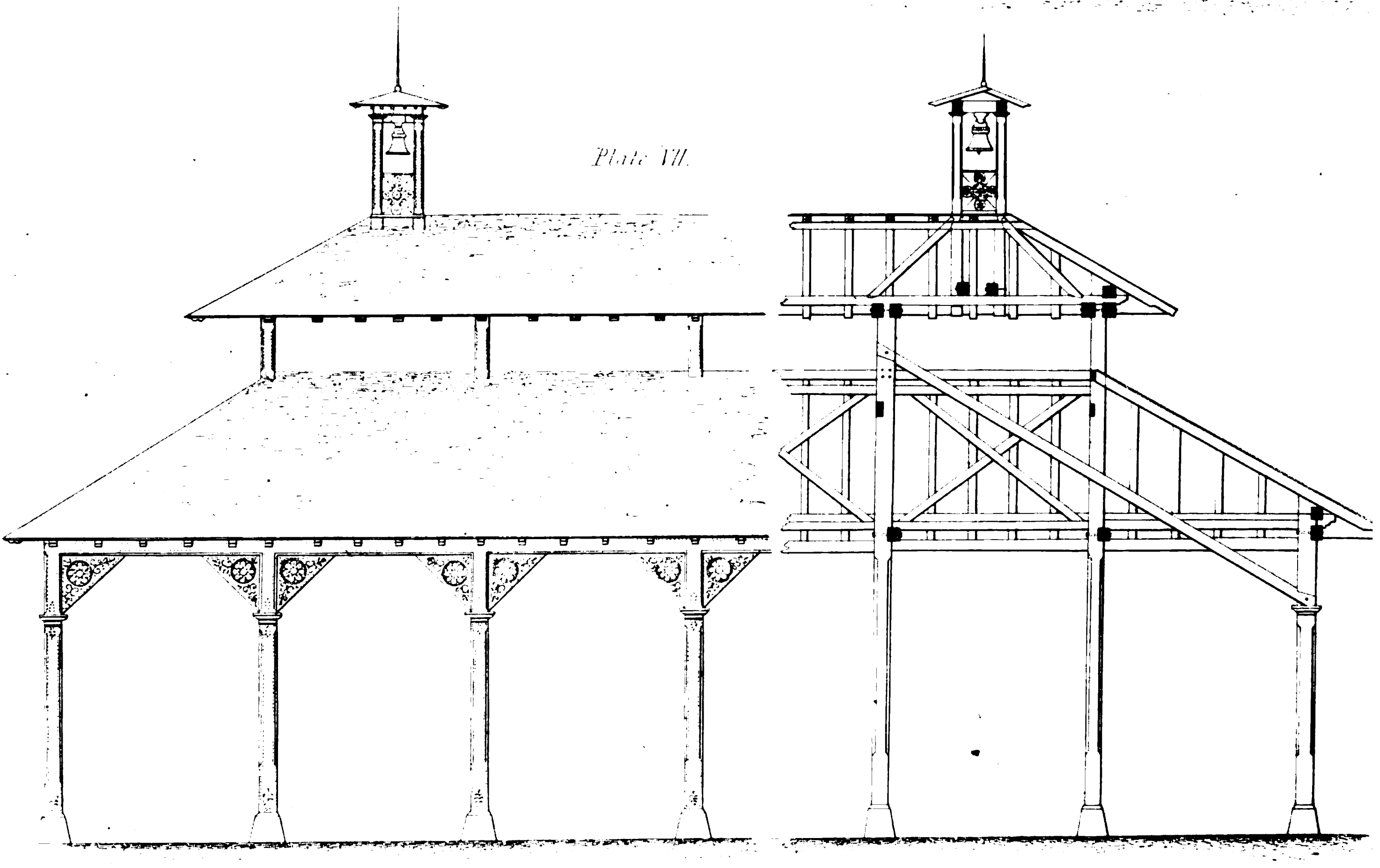
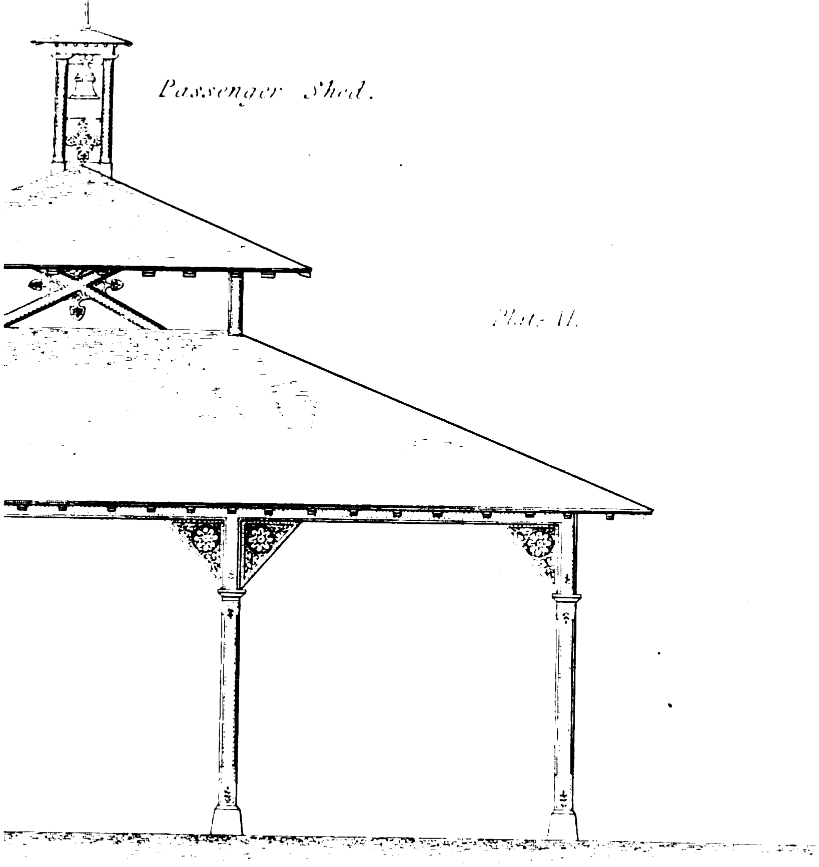


Plate VII.

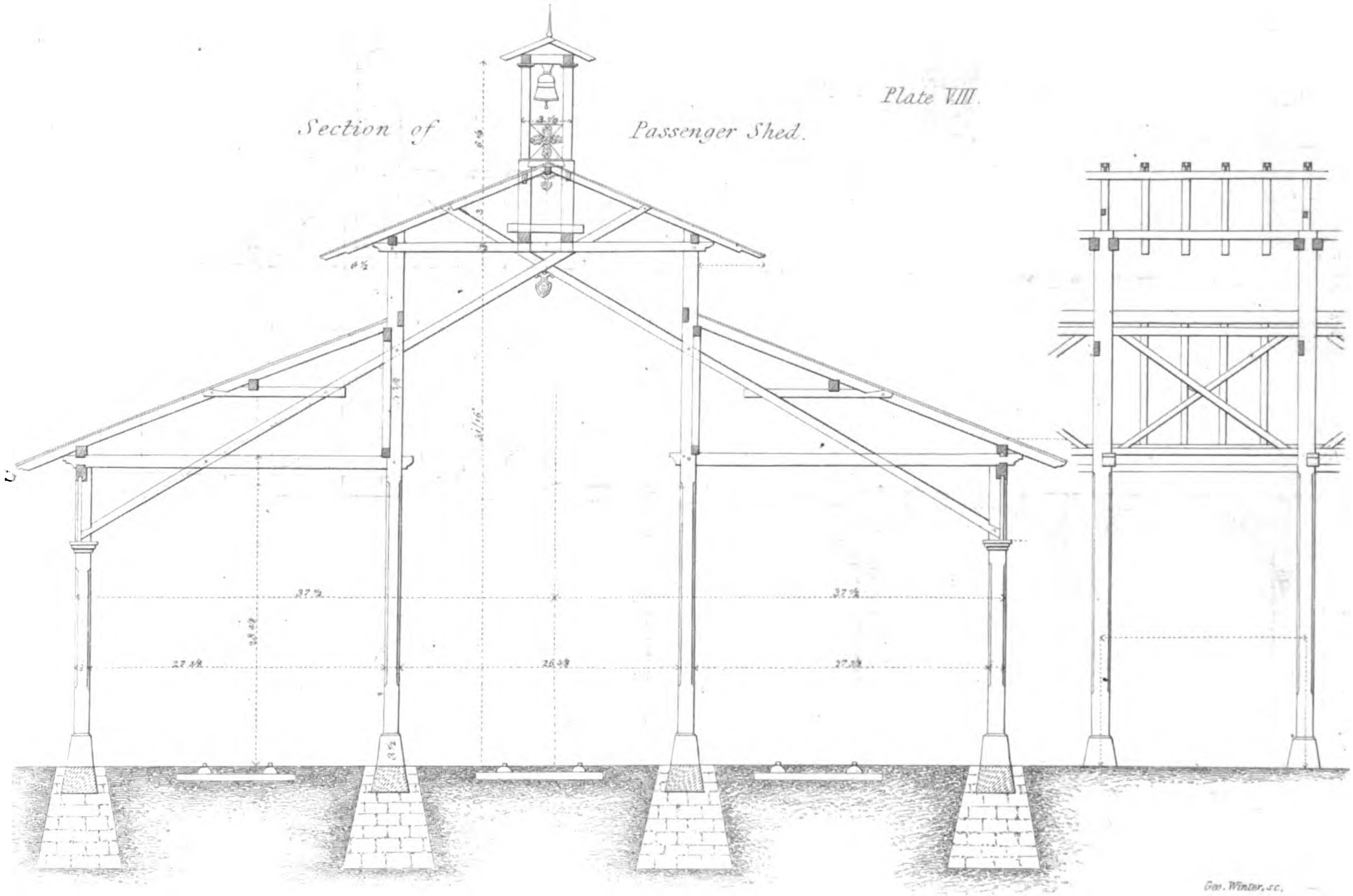


ESBADEN RAILWAY.



Passenger Shed.

Plate VI.



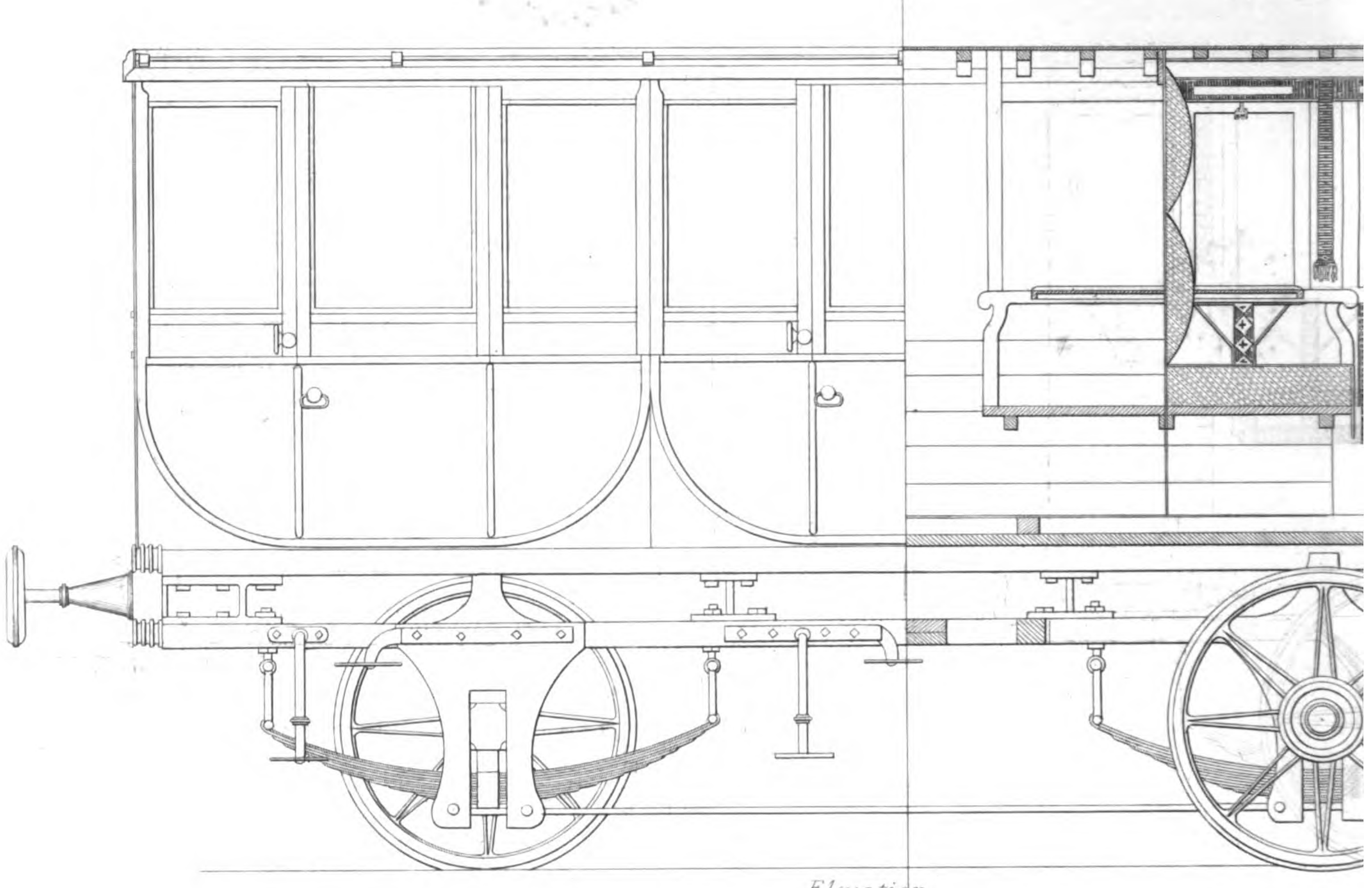
Section of Passenger Shed.

Plate VIII.

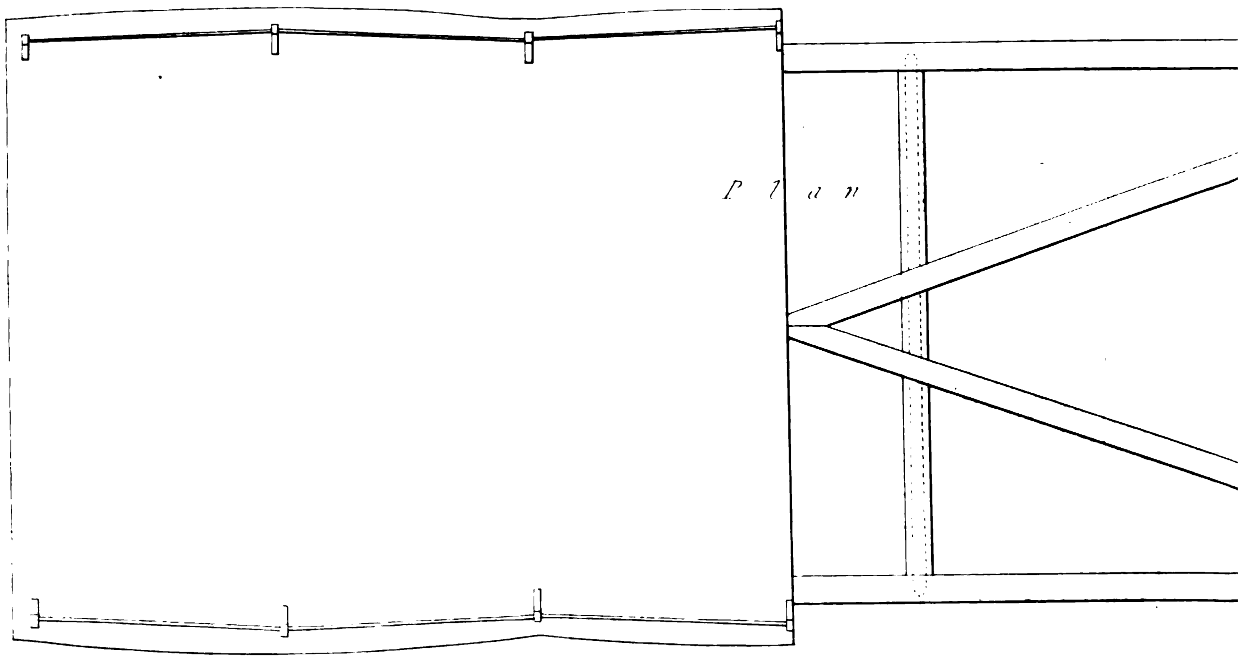
Geo. Winter, sc.

FRANKFURT & WIE

1st Class



Elevation

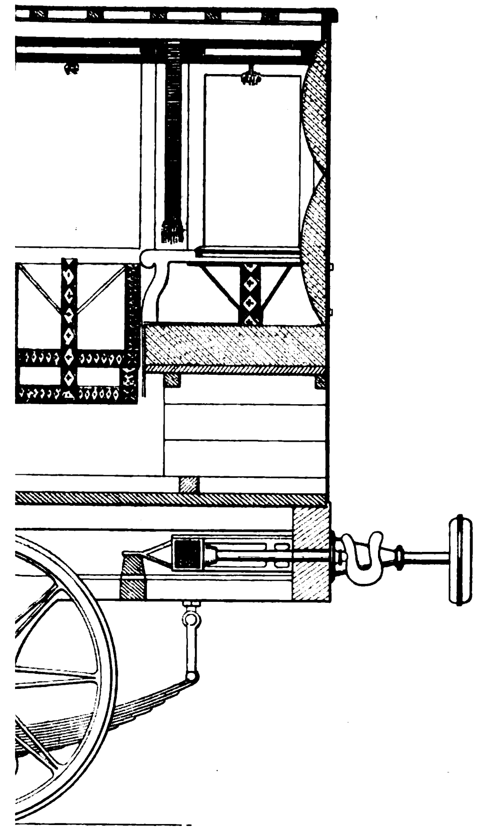


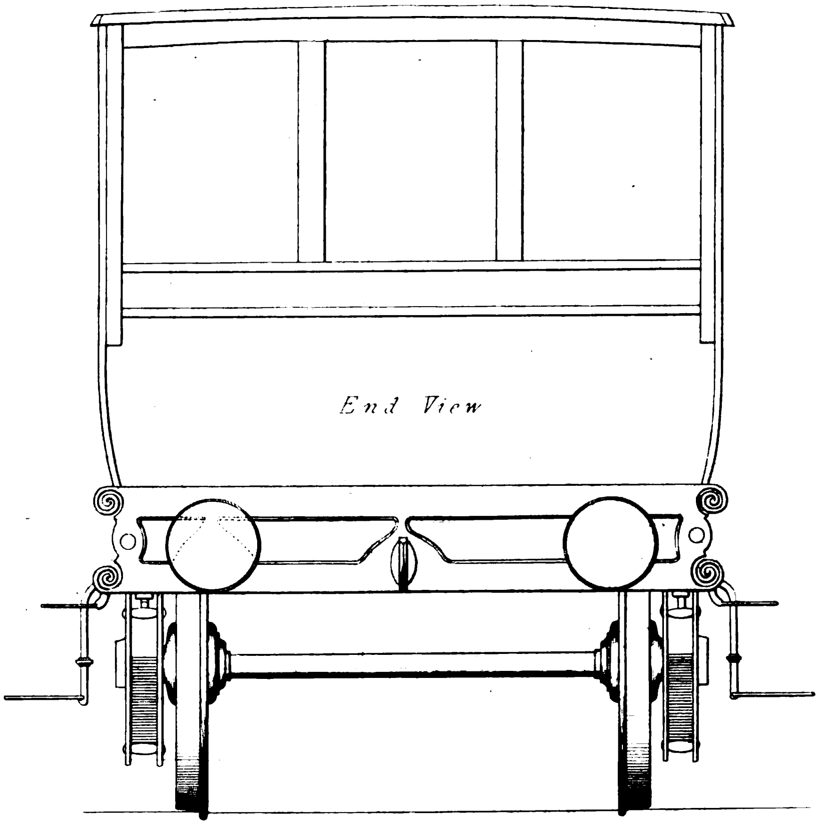
Plan

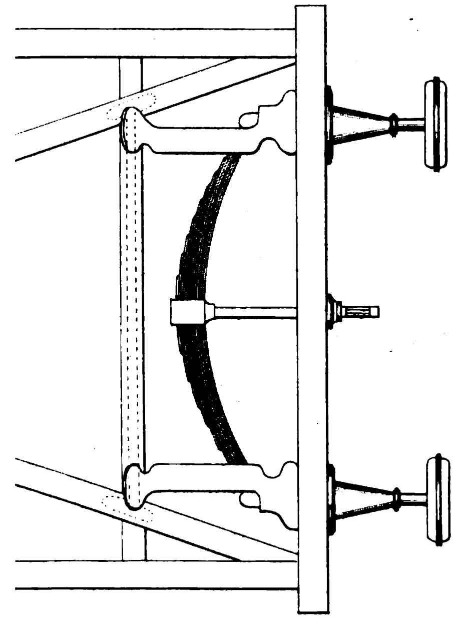
SBADEN RAILWAY.

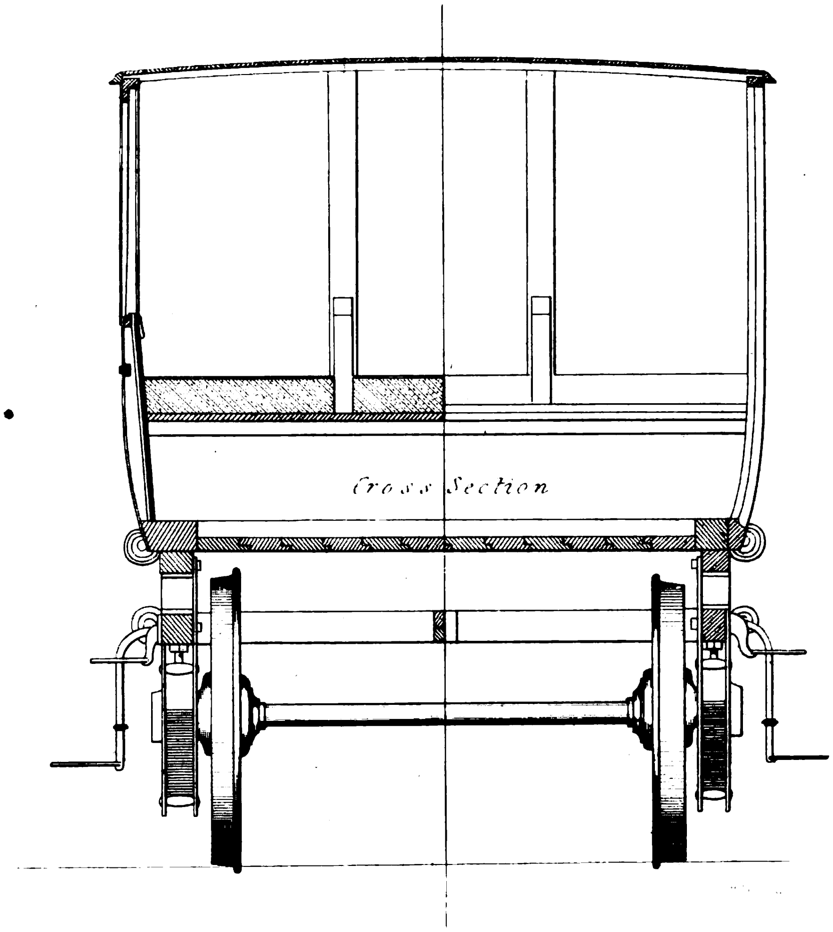
arriages.

Plate IX





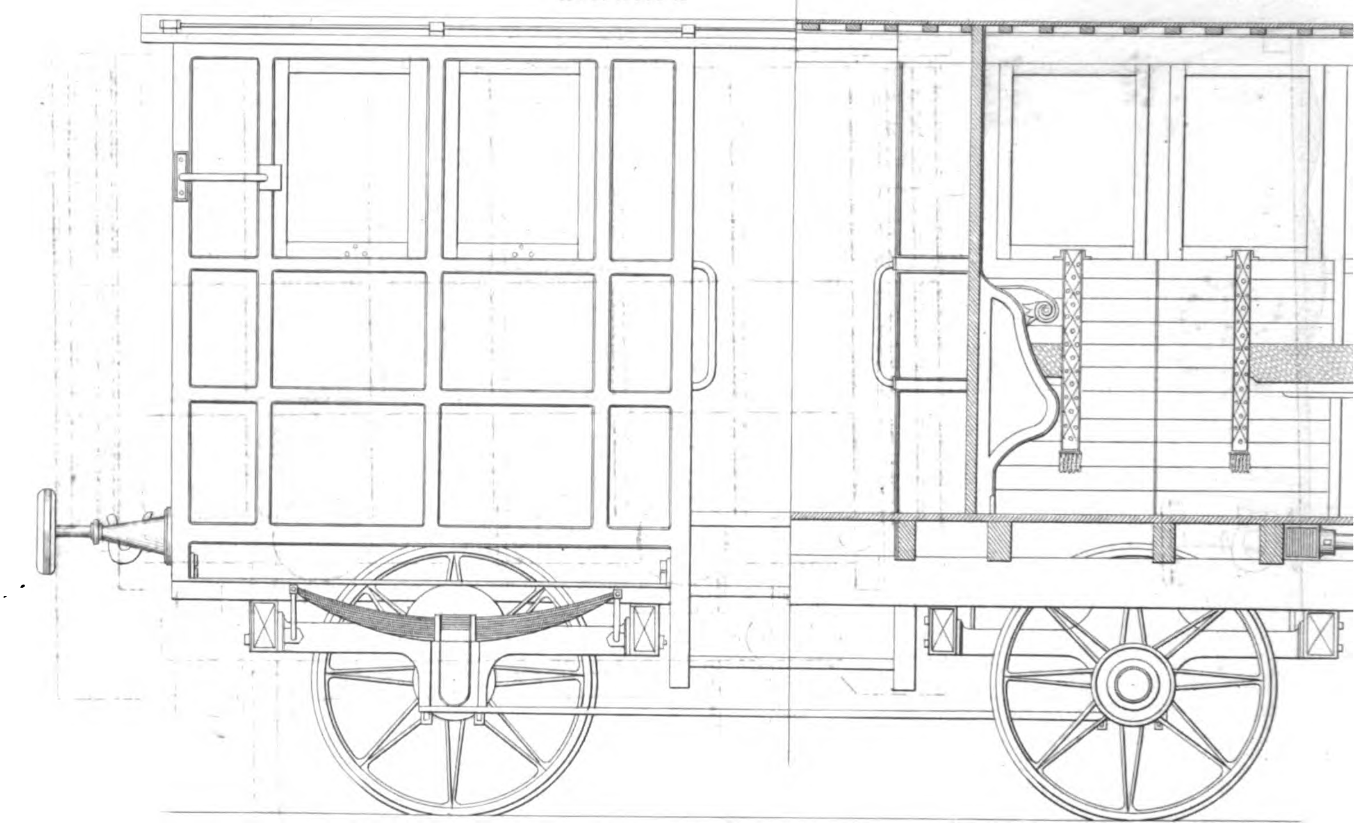


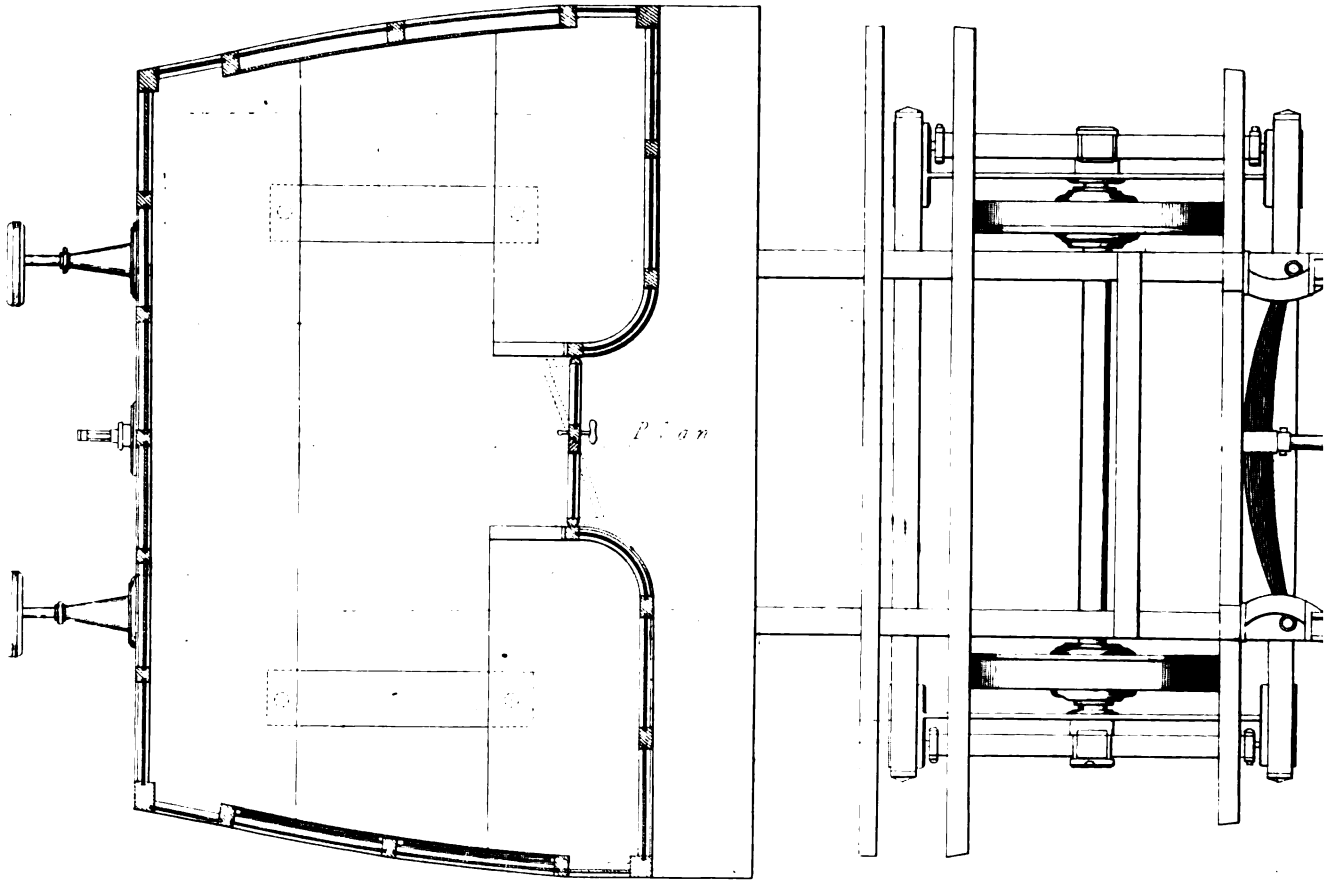


FRANKFURT & WIES

2nd Class

Elevation





BADEN RAILWAY.

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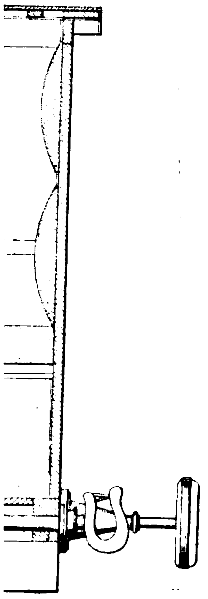
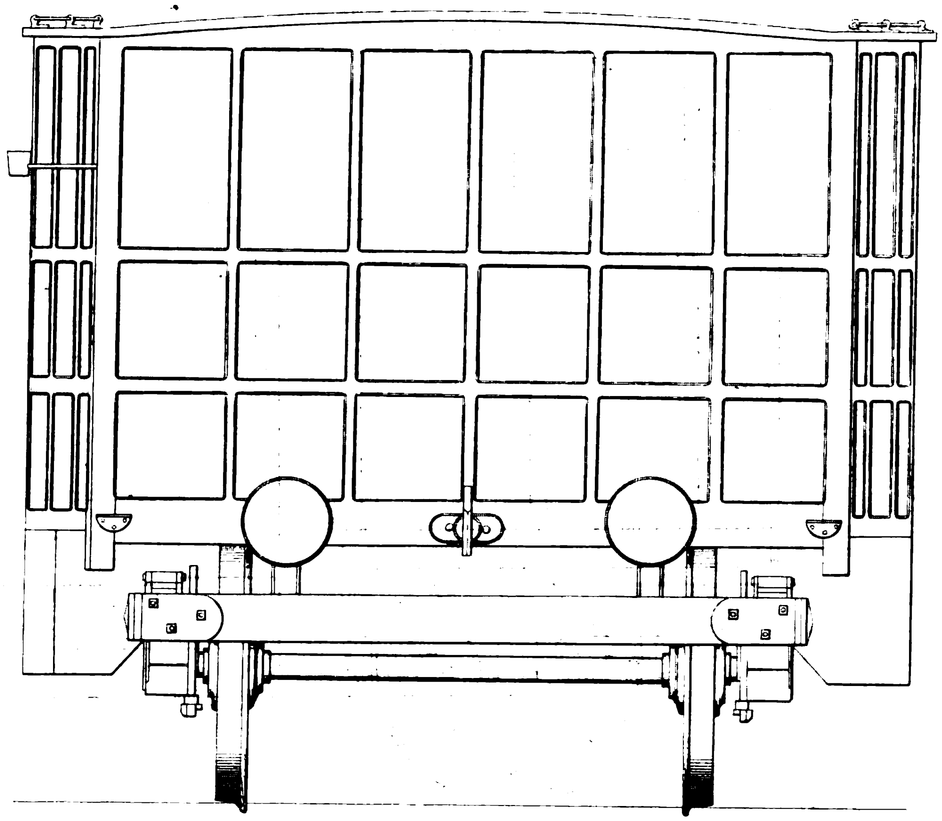
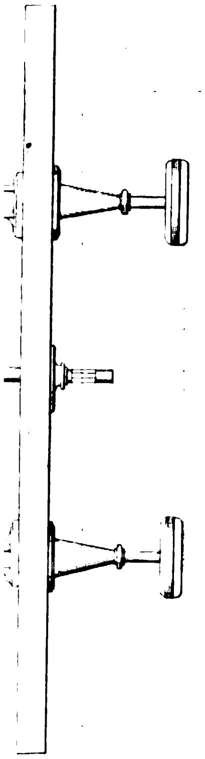
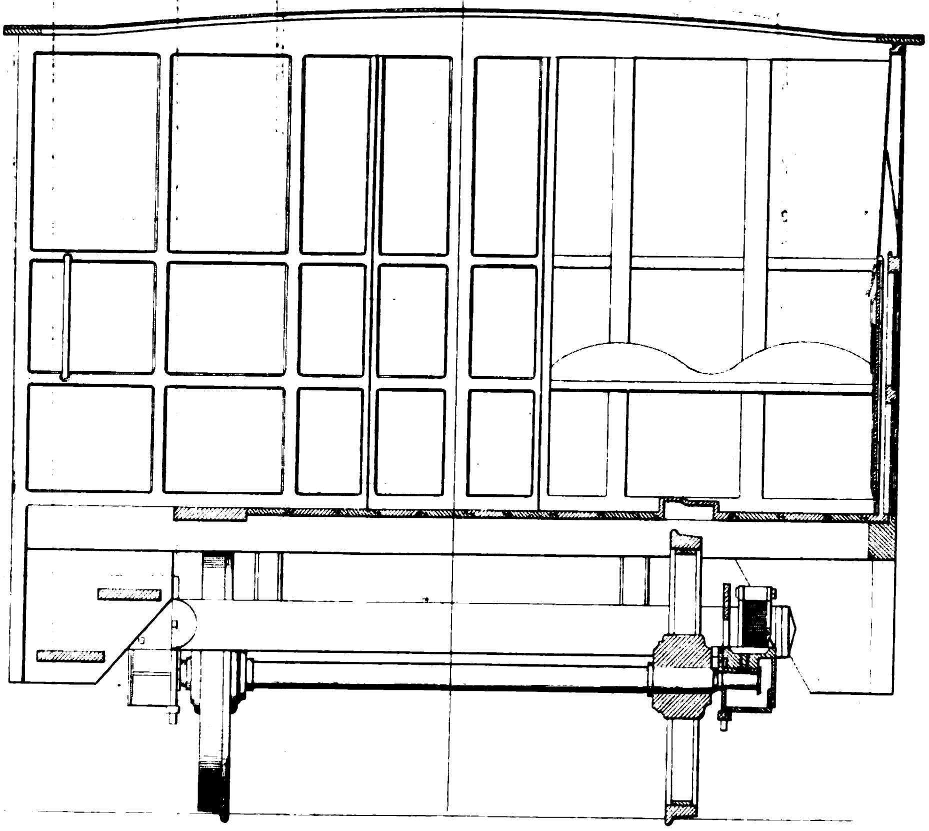


End View



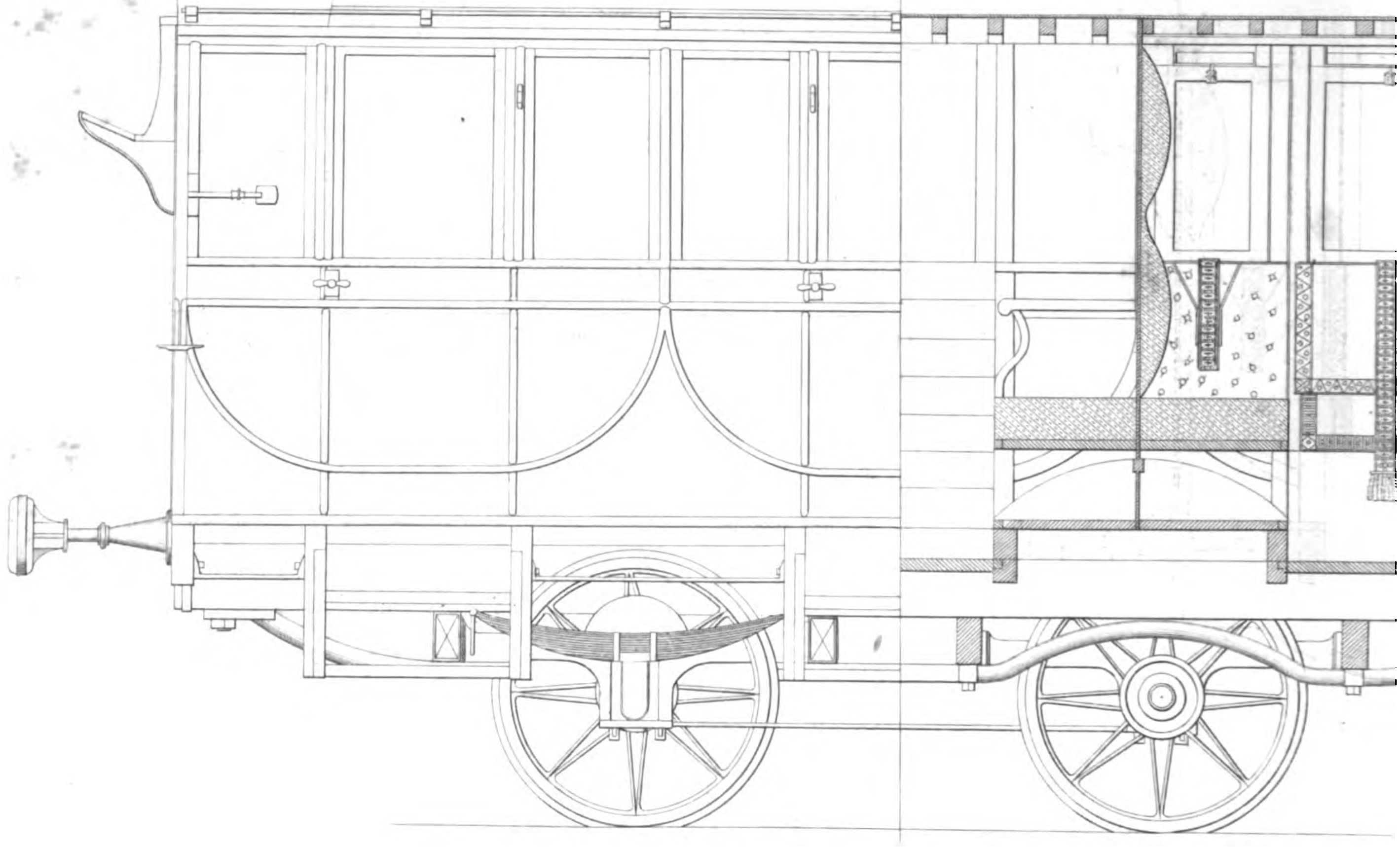


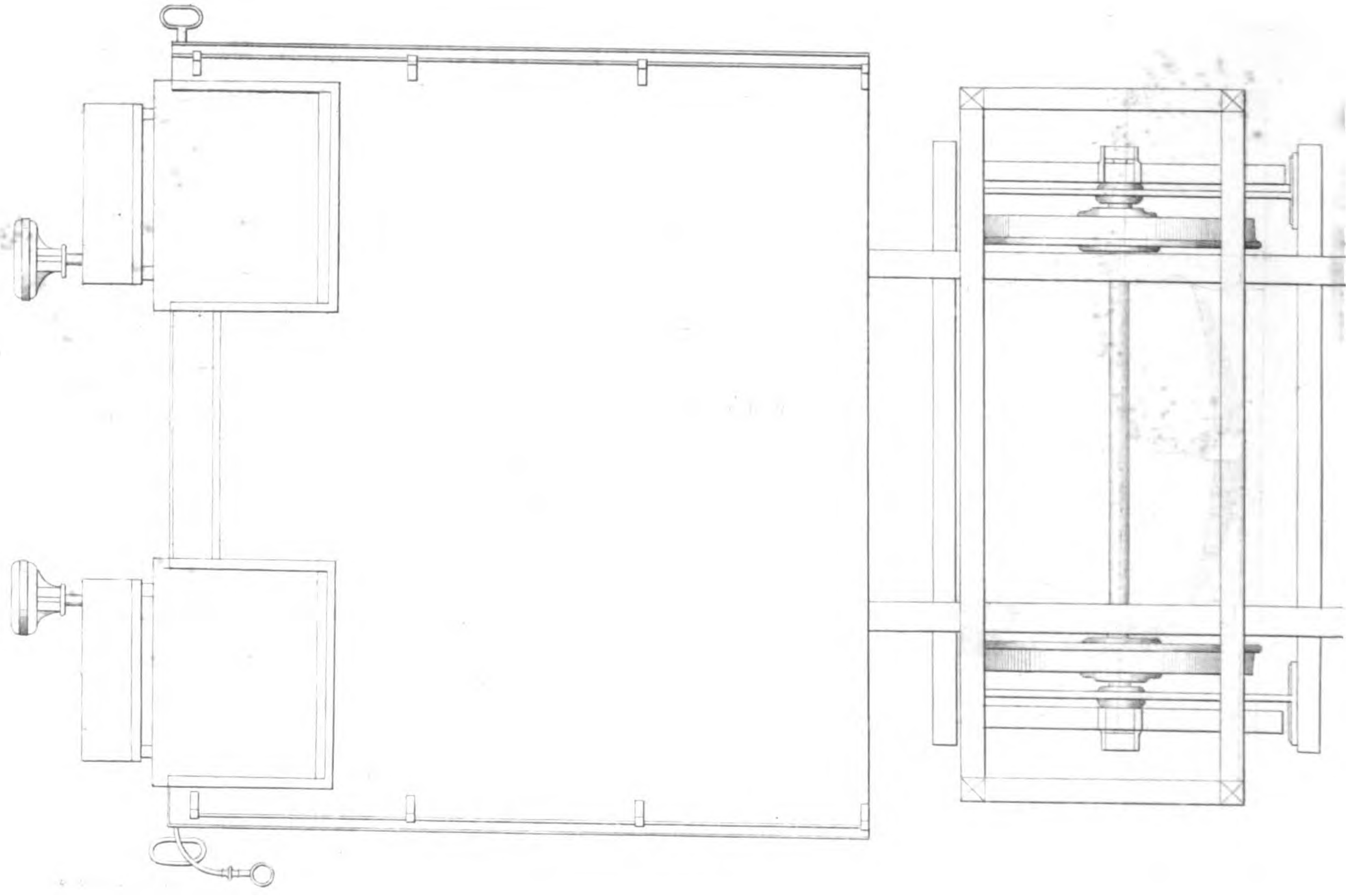
Cross Section



FRANKFURT & WI
Mixed or 1st & 2nd

Elevation





SBADEN RAILWAY.

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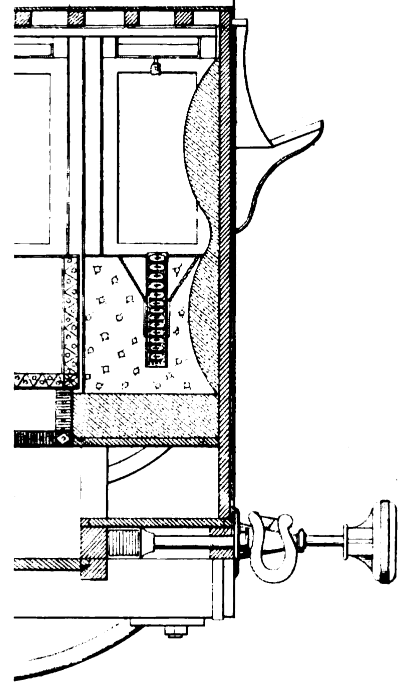
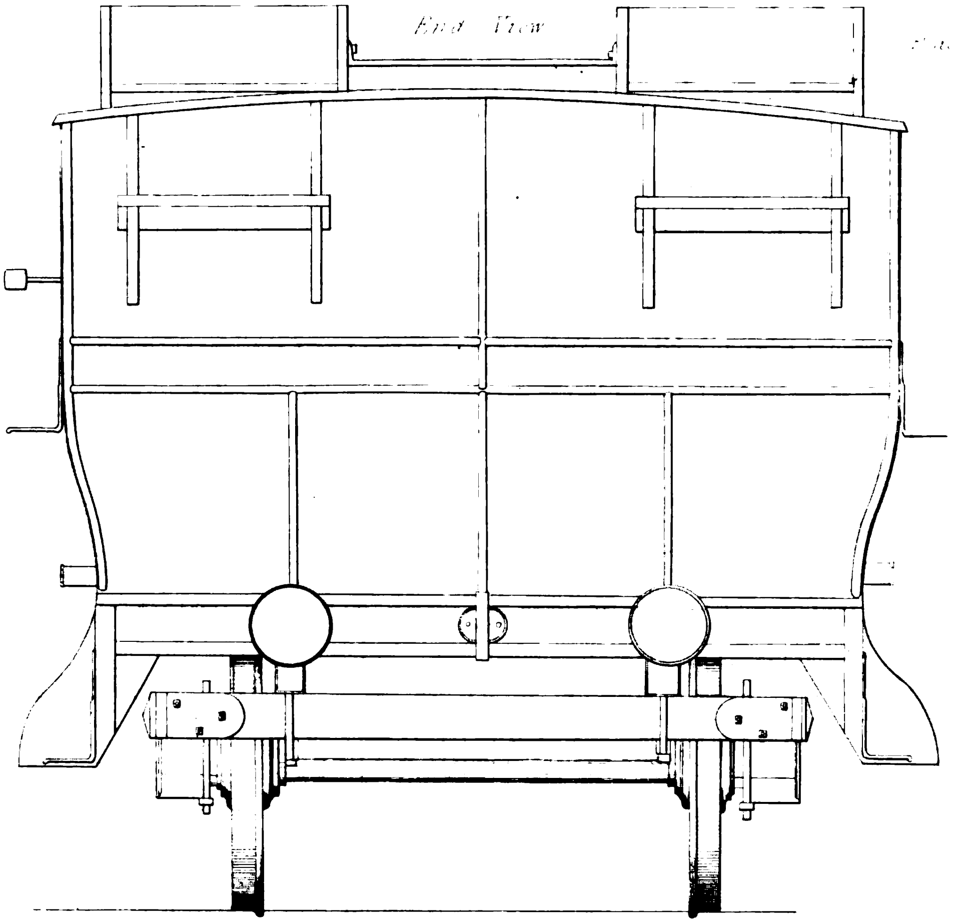
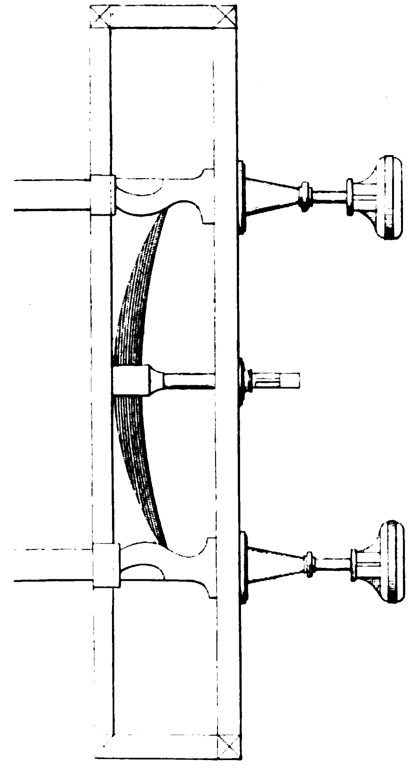
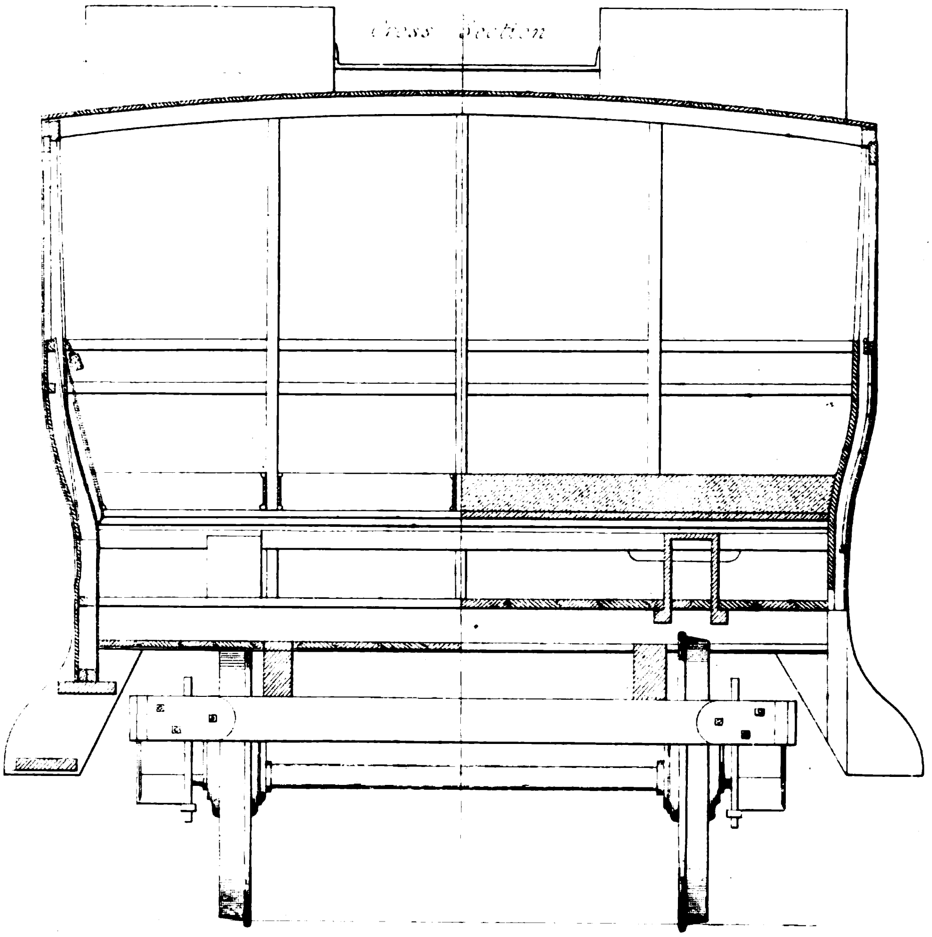
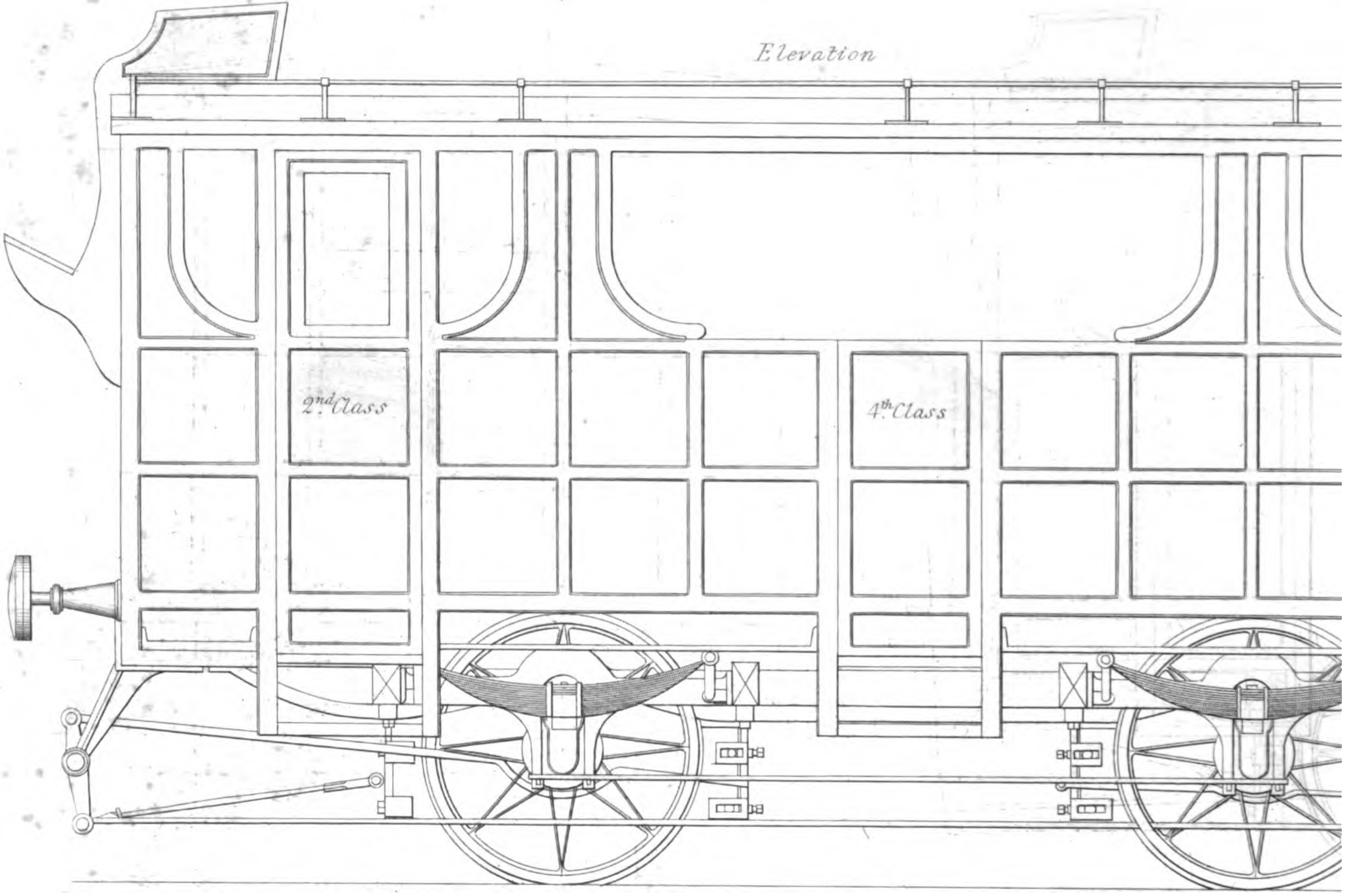


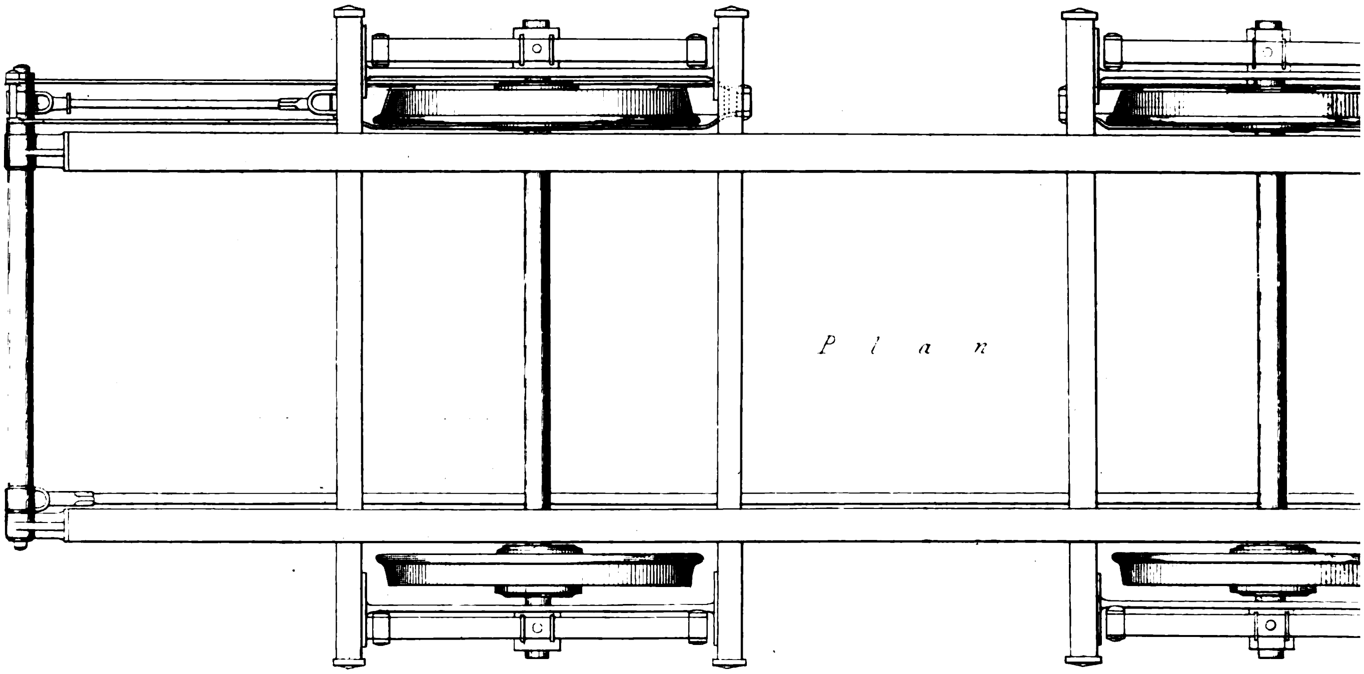






FRANKFURT & WIESBADE





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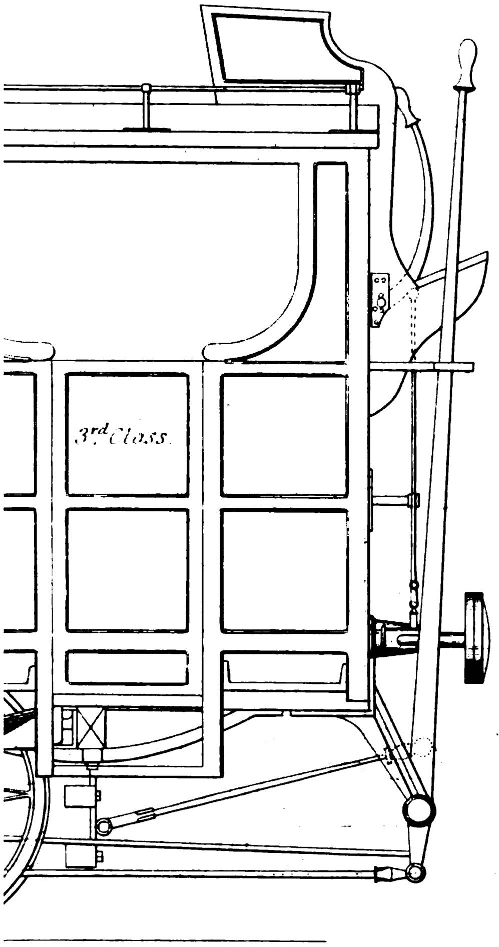
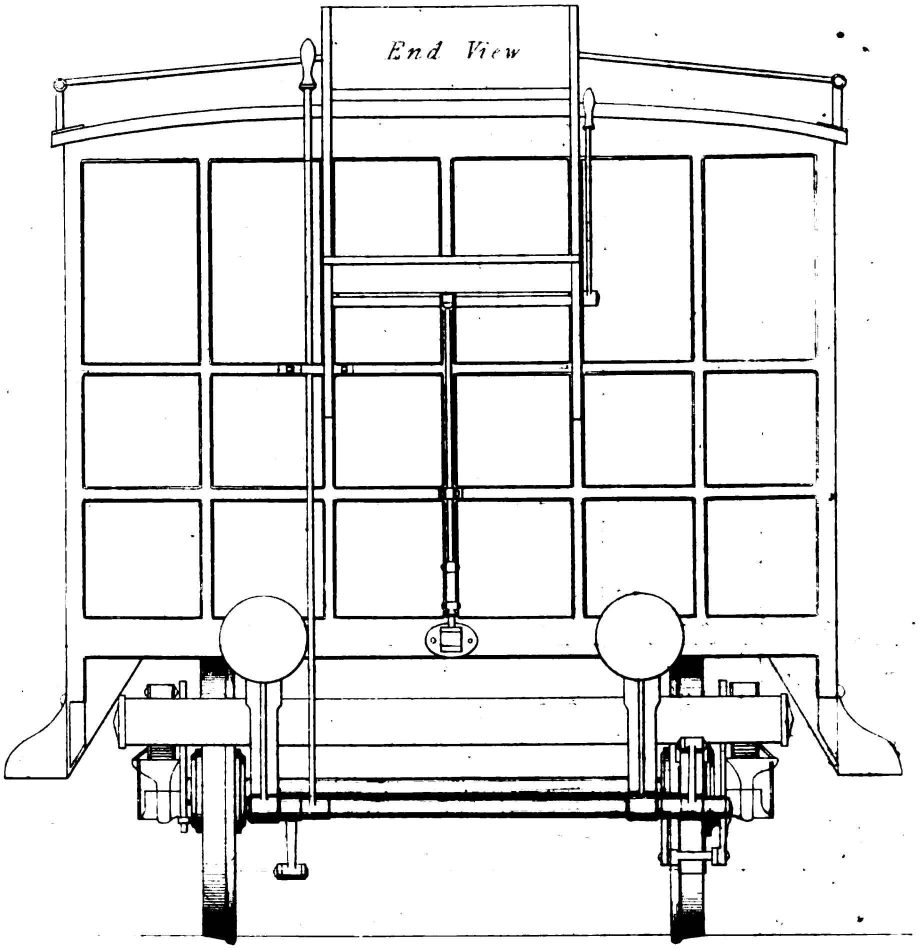
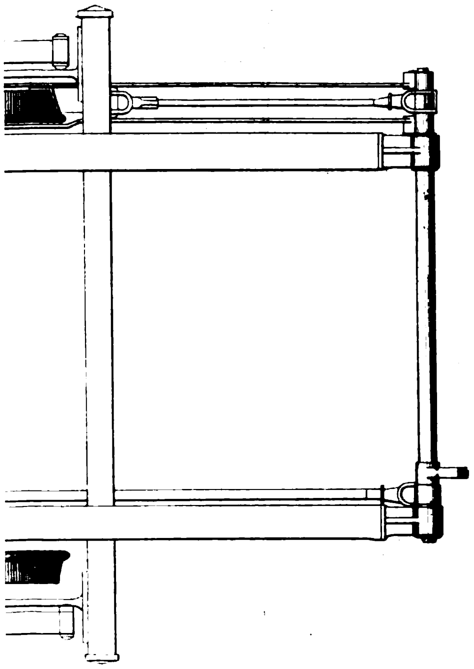
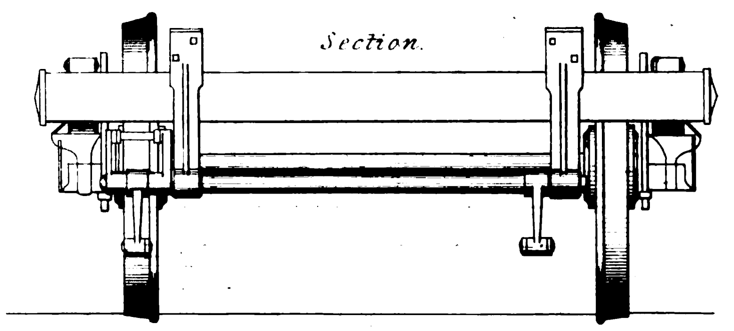
London, [illegible]









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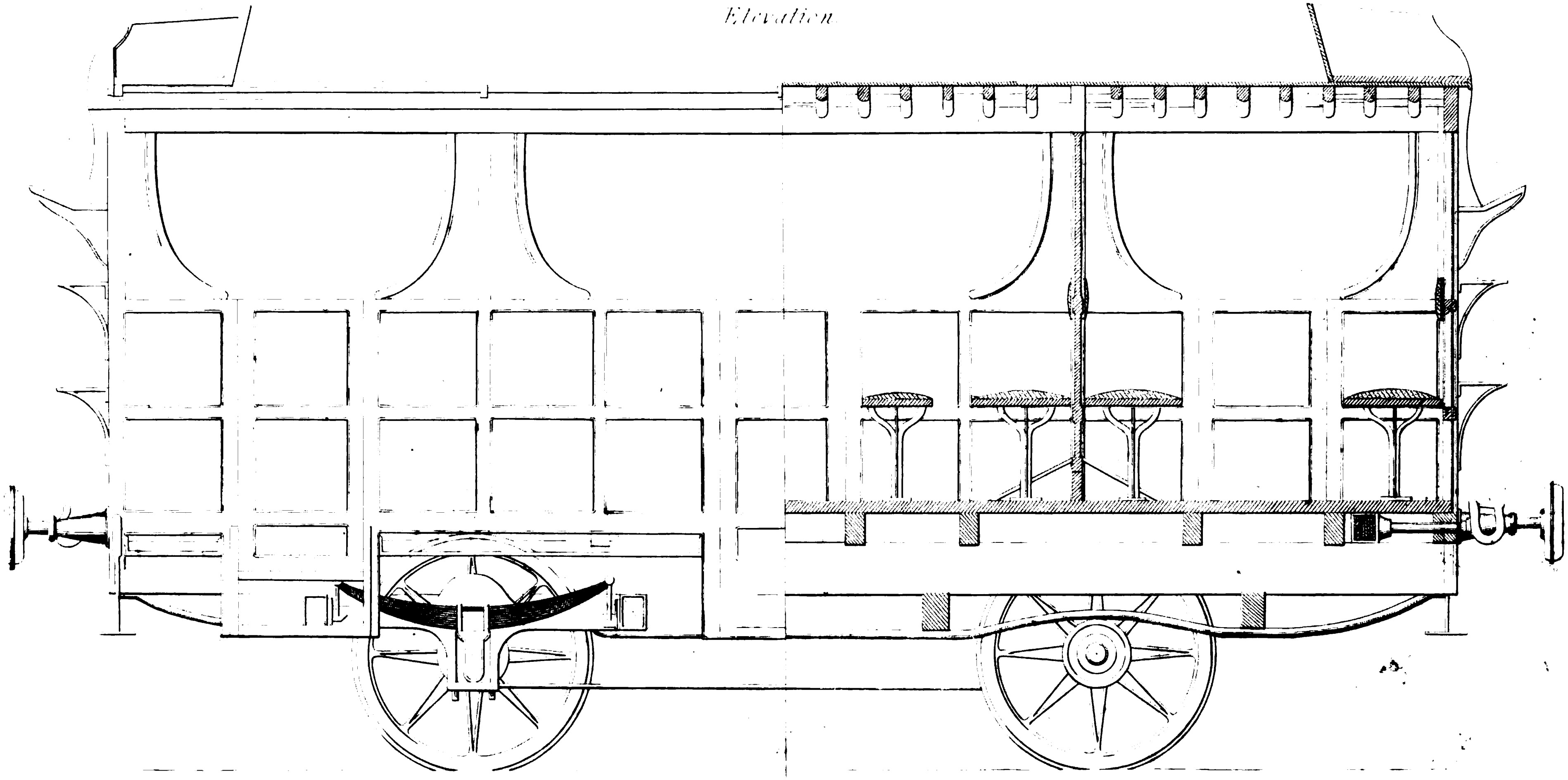
Geo. Winter, sc.

FRANKFURT & WIESBADEN RAILWAY.

3rd Class Carriages.

Elevation.



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London. John Weale, 1846.

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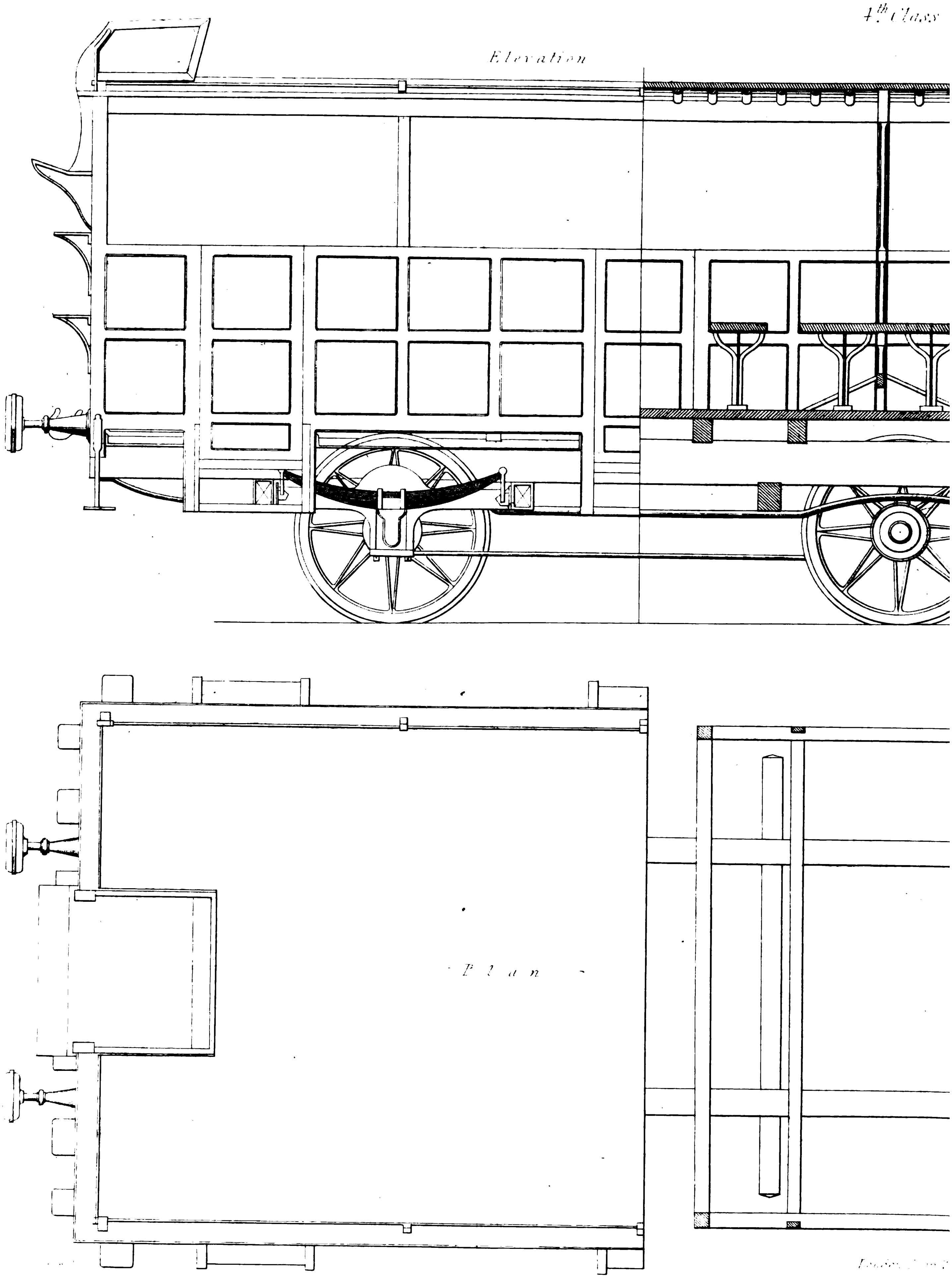
FRANKFURT & WIE

4th Class

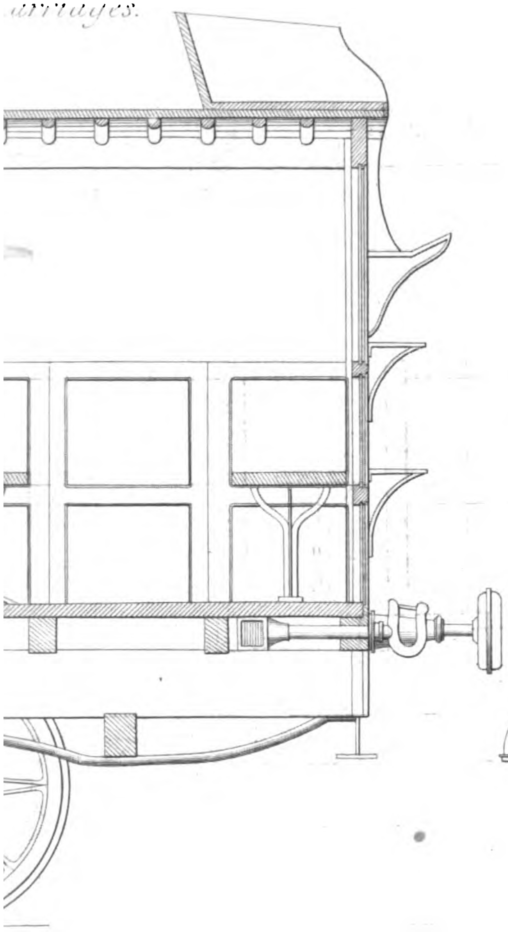


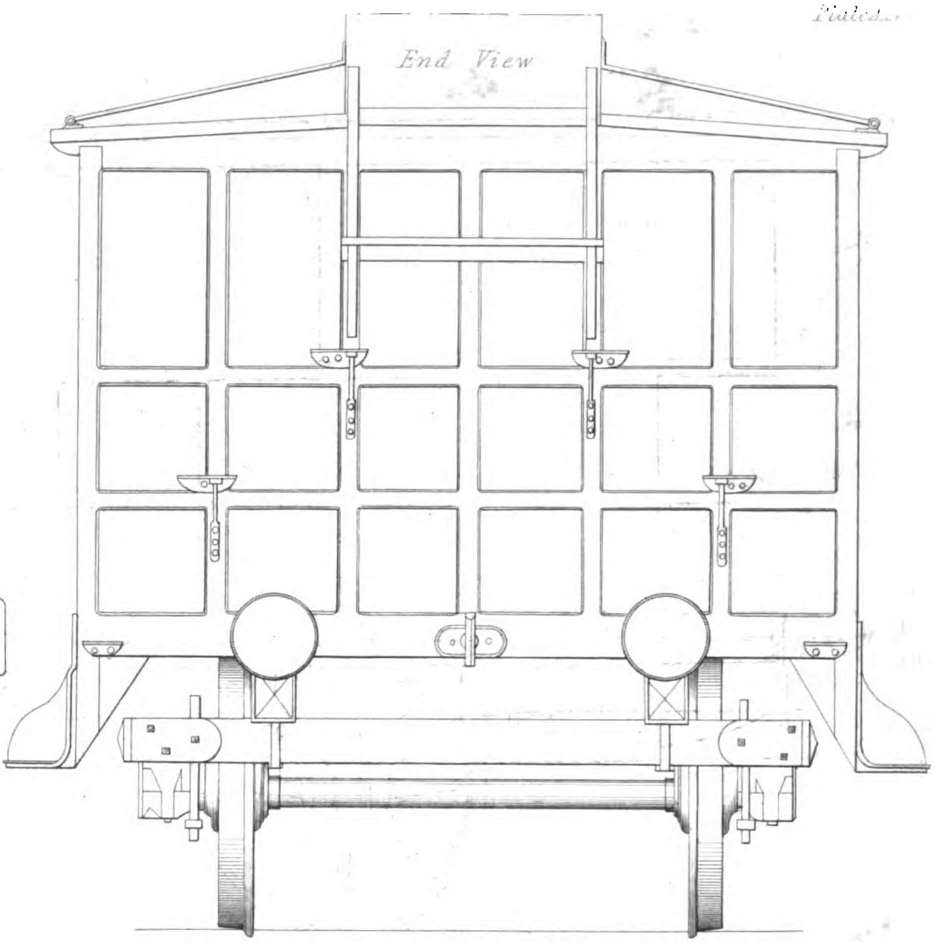
London,

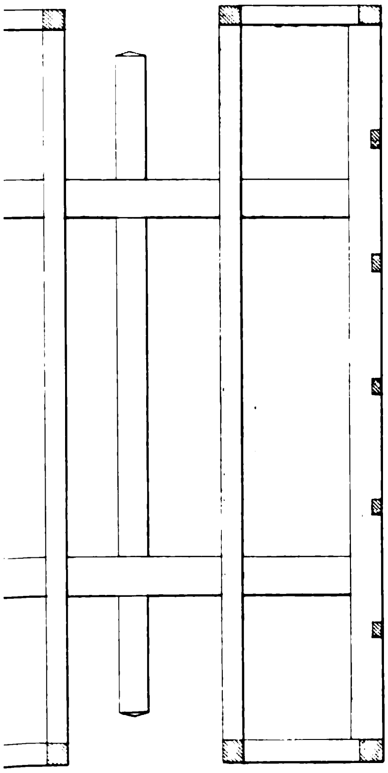
SBADEN RAILWAY.

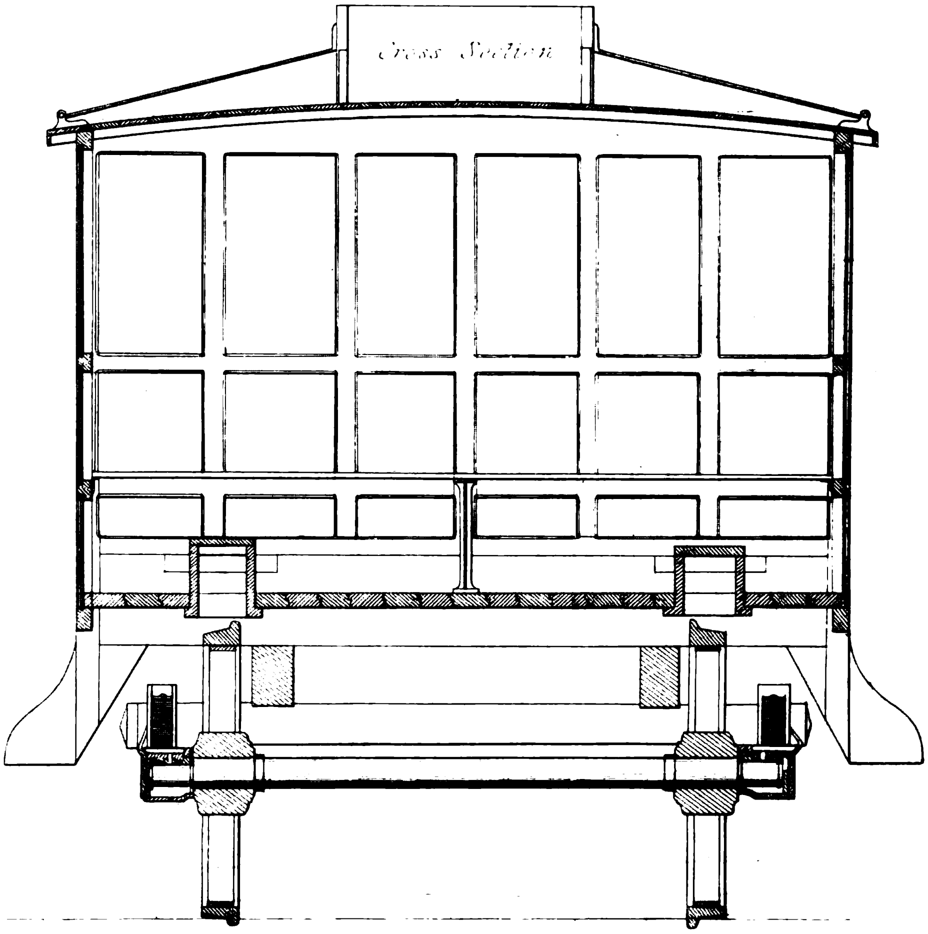
arriages.

Plate



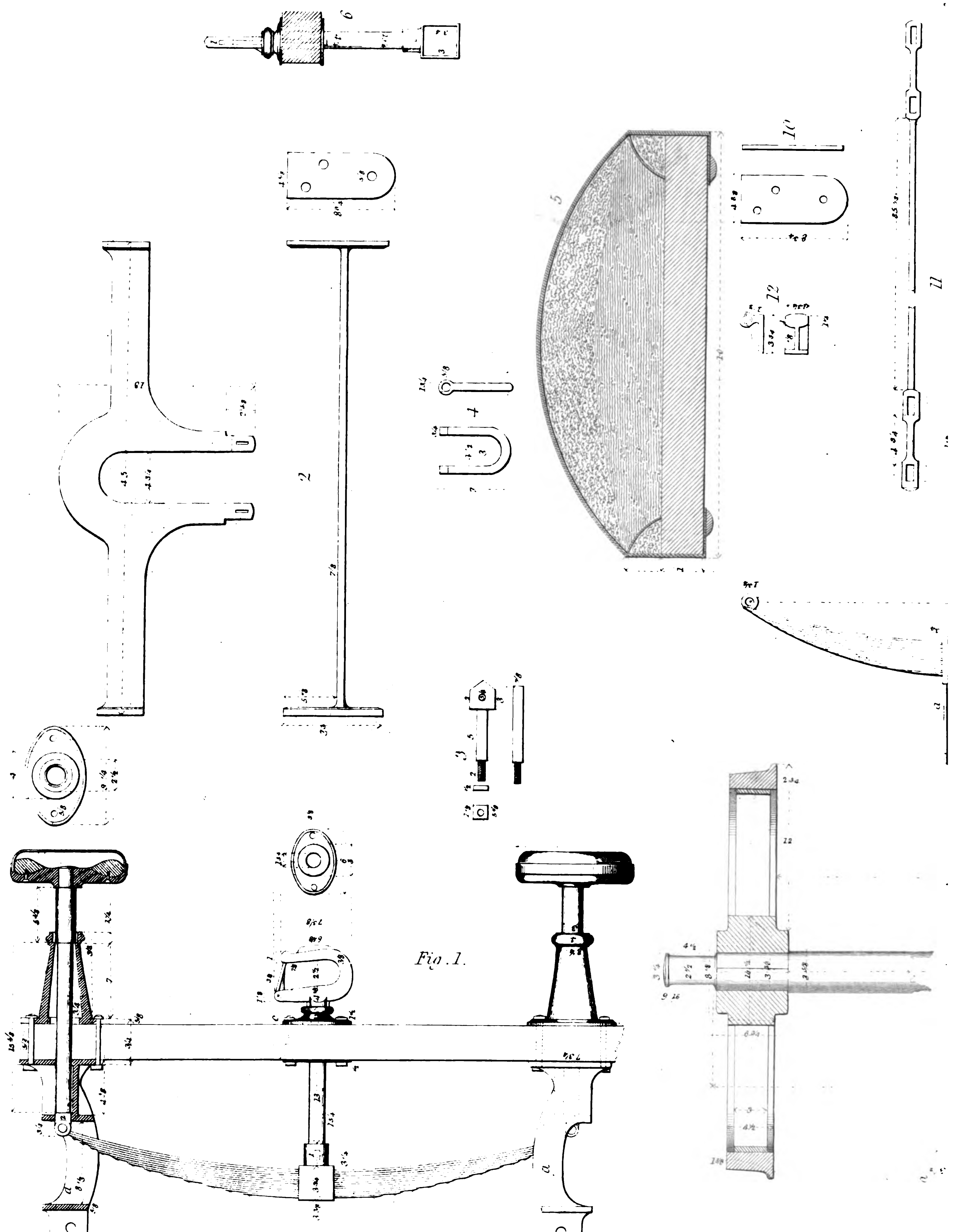






FRANKFURT & WI

Details

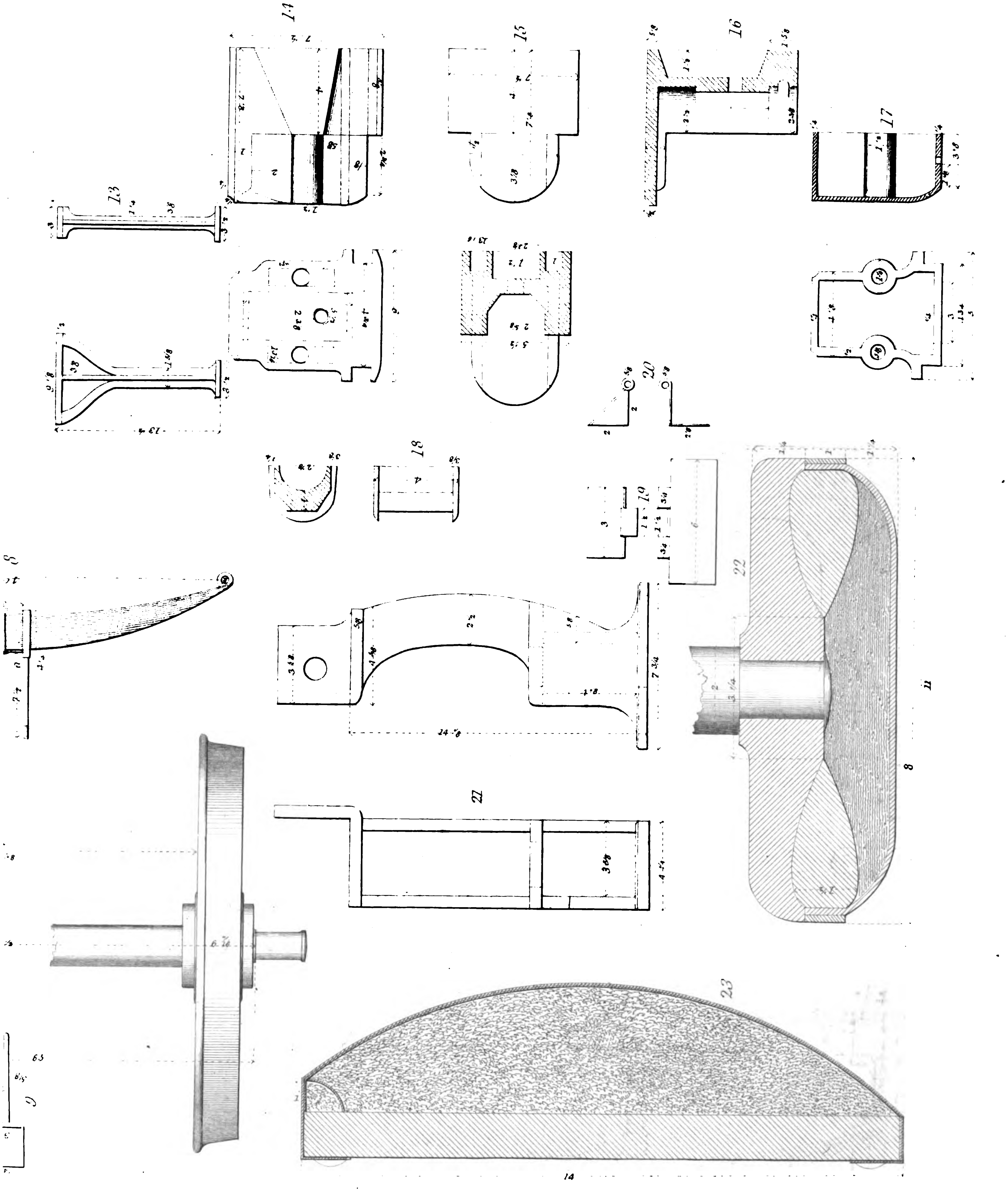


G. B. Dempsey del

London

S BADEN RAILWAY.
Carriages.

Plate XV to XVII.



FRANKFURT & WIESBADEN RAILWAY.

Fig. 1.

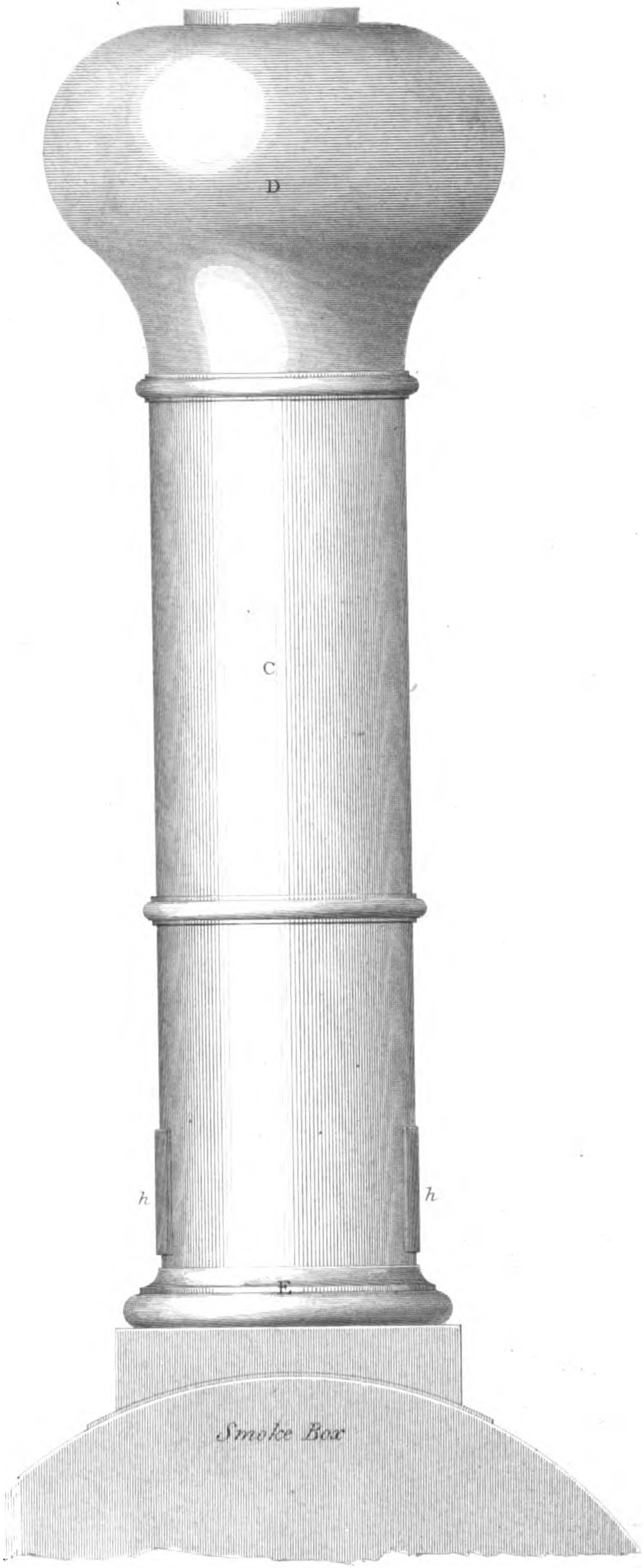
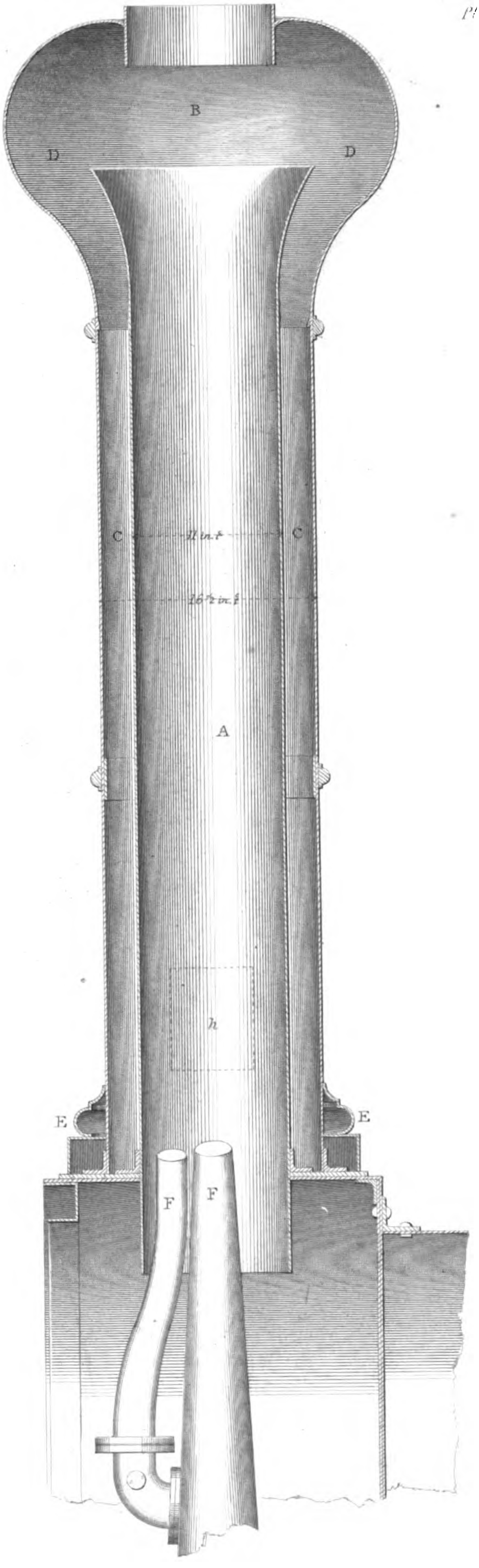


Fig. 2.



London, John Weale 18[illegible]

Plate. 1º.

Fig. 1.

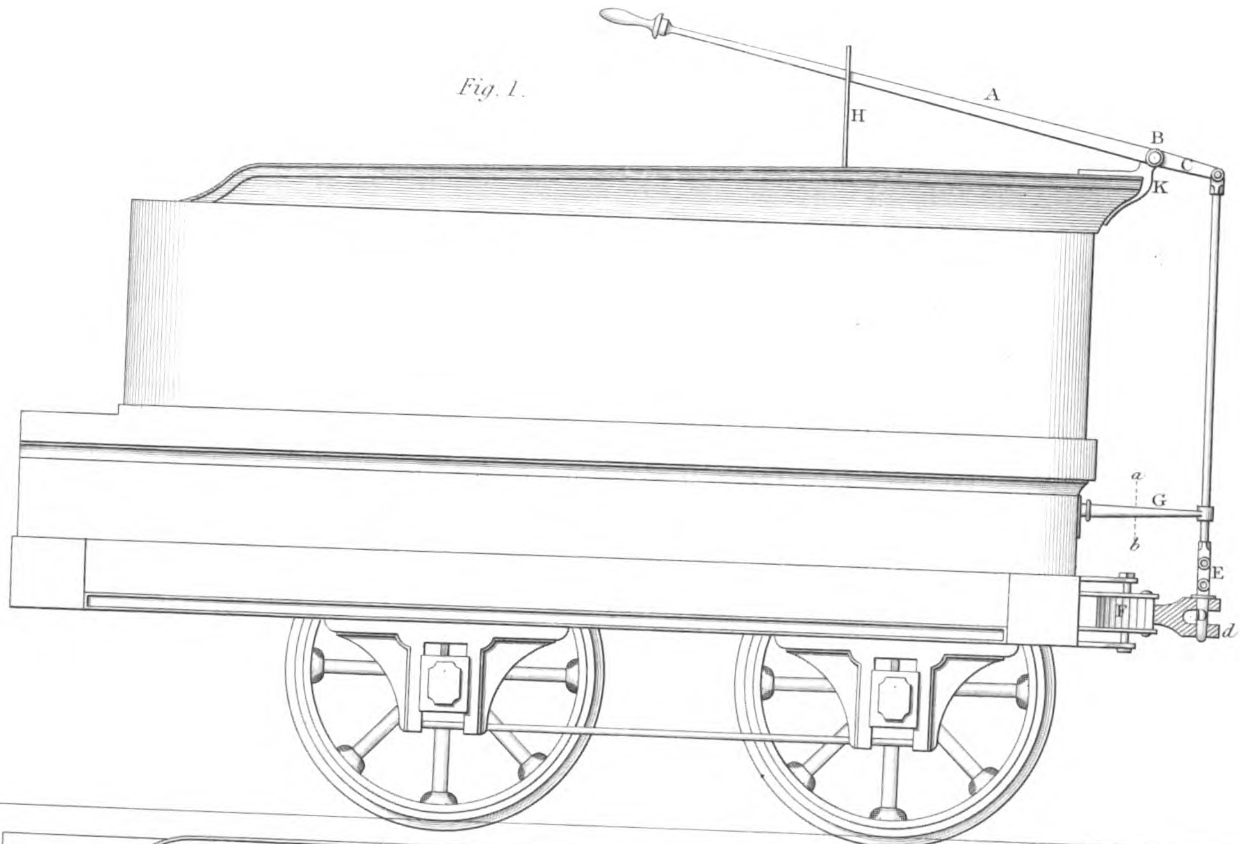


Fig. 2.

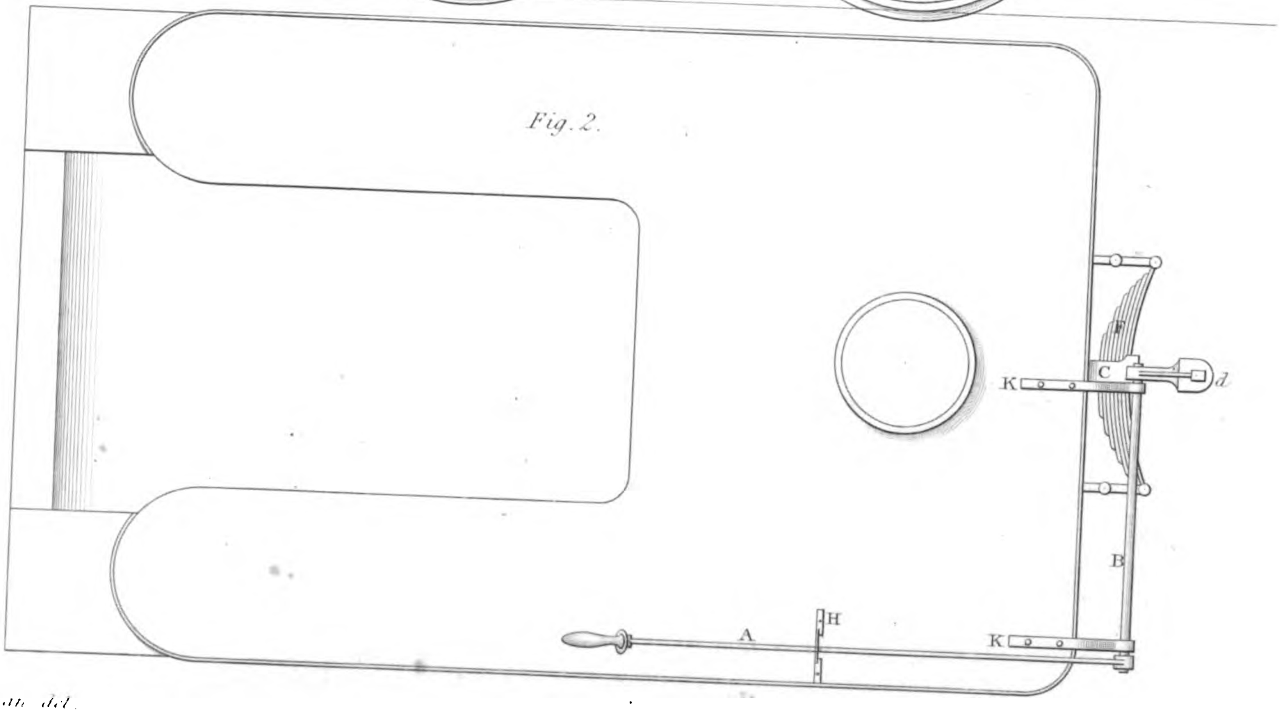


Fig. 3.

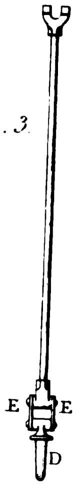


Fig. 4.

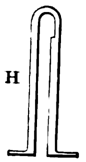
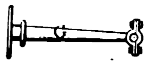


Fig. 5.

Fig. 6.



Detaching Apparatus:
TAUNUS RAILWAY.
by Robt. Thorman.
ENGINEER

Scale 1/2 In. to a Foot.

R. Thorman. del.

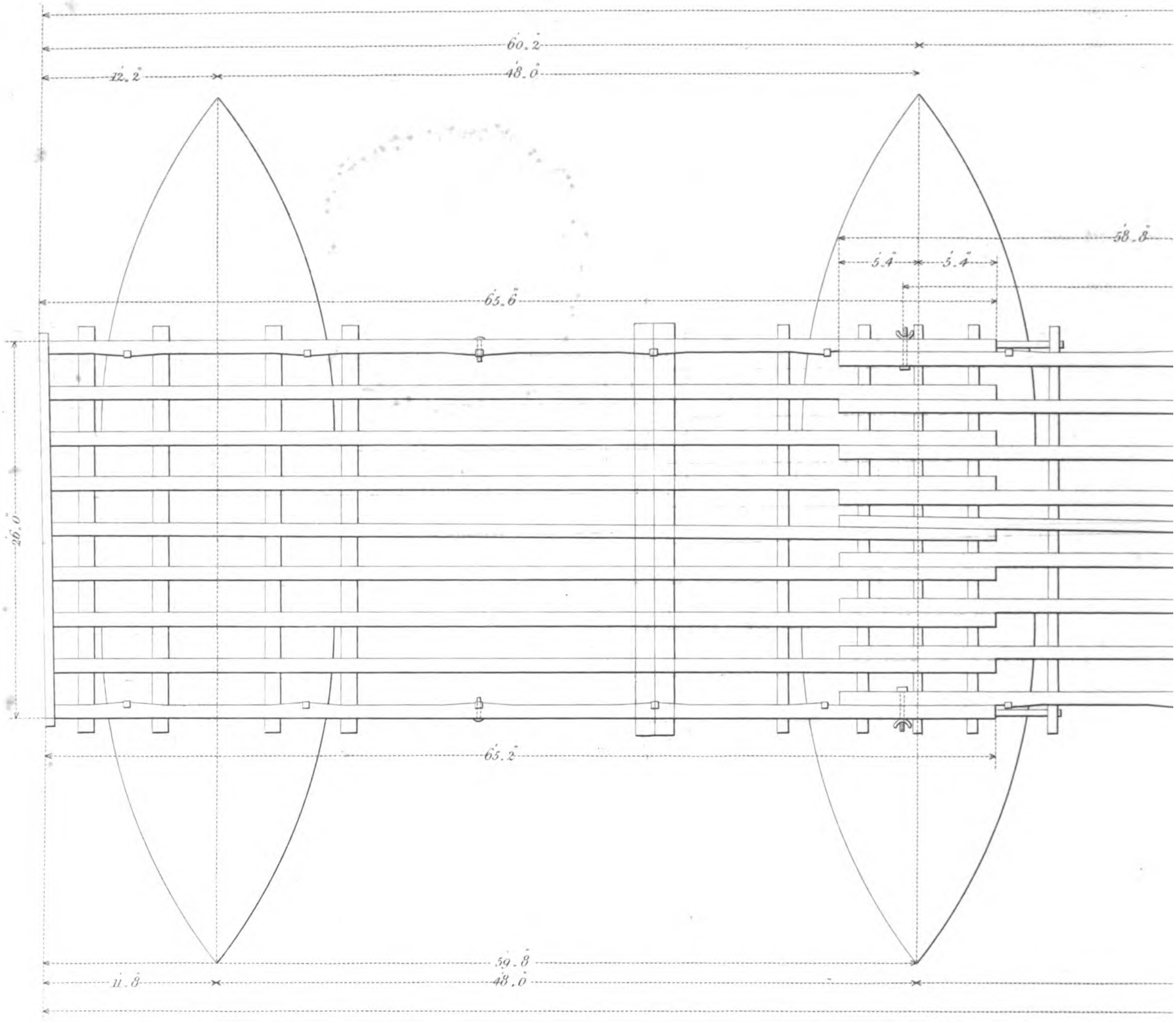
John Weale, Architectural Library, 59 High Holborn. 1846.

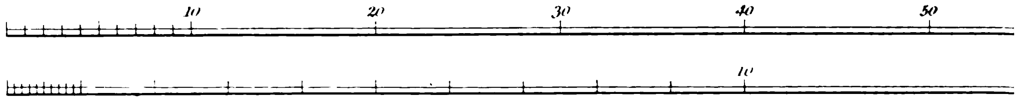
W. A. Beever. sc.

BRIDGE O

ACROSS THE RHINE AT

(The Frankfort Railw





John Weale, Architectural

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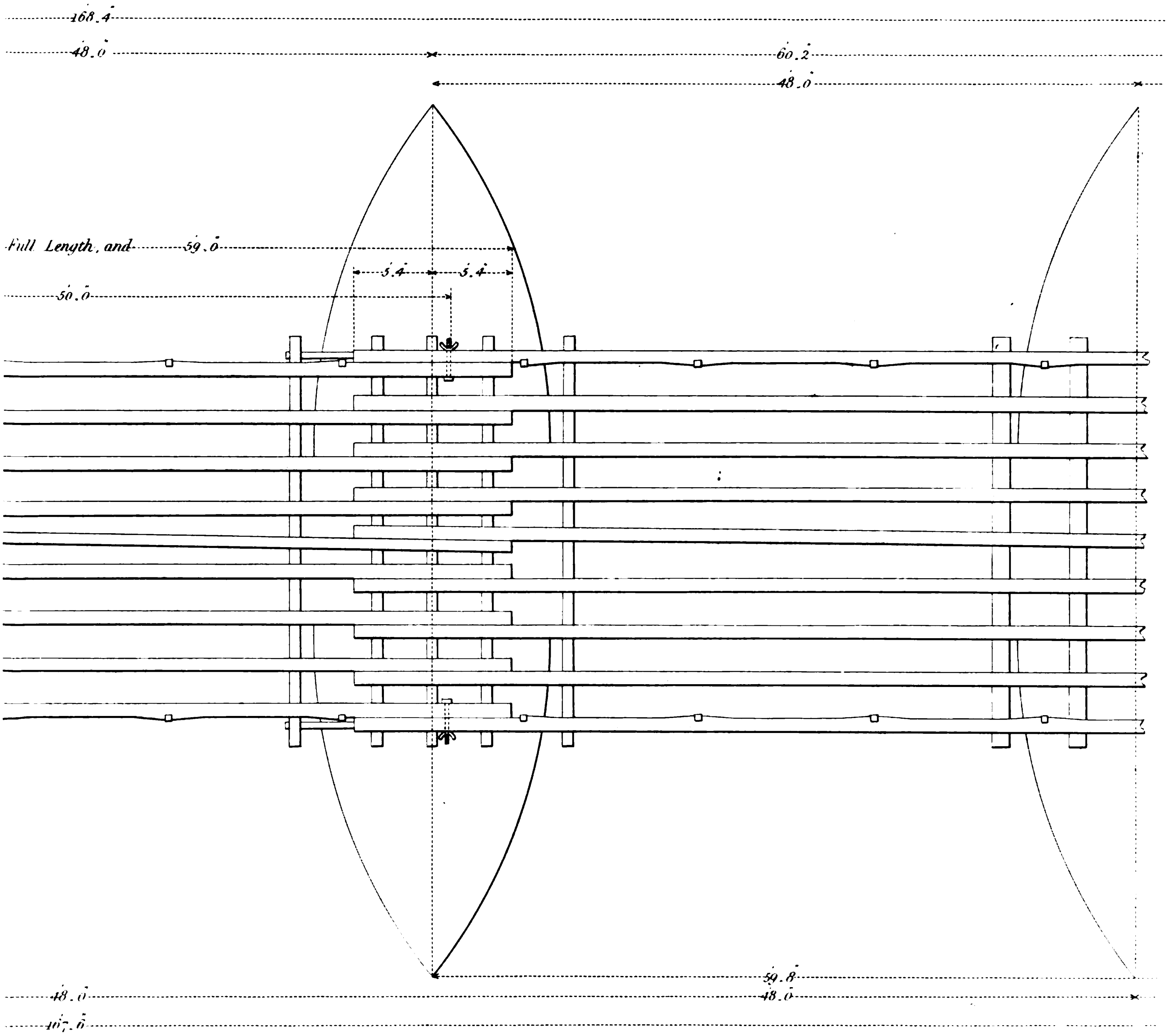

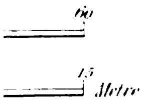

Take Notice, that this Bridge is built with a sweep across the Rhein, which accounts for the two dimensions.

rey 59 High Holborn, 1816

BRIDGE

ACROSS THE RHINE

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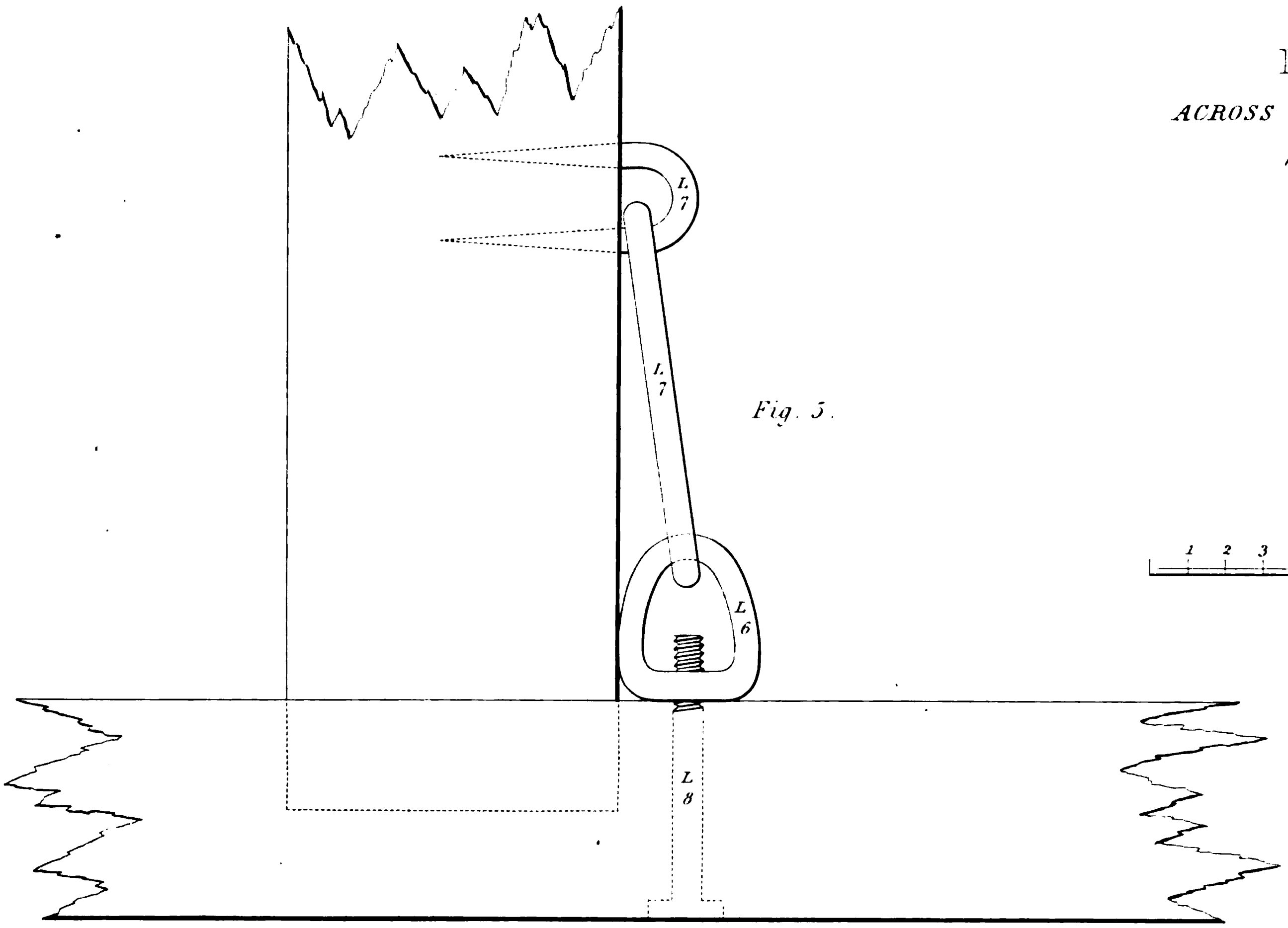

Fig. 5.

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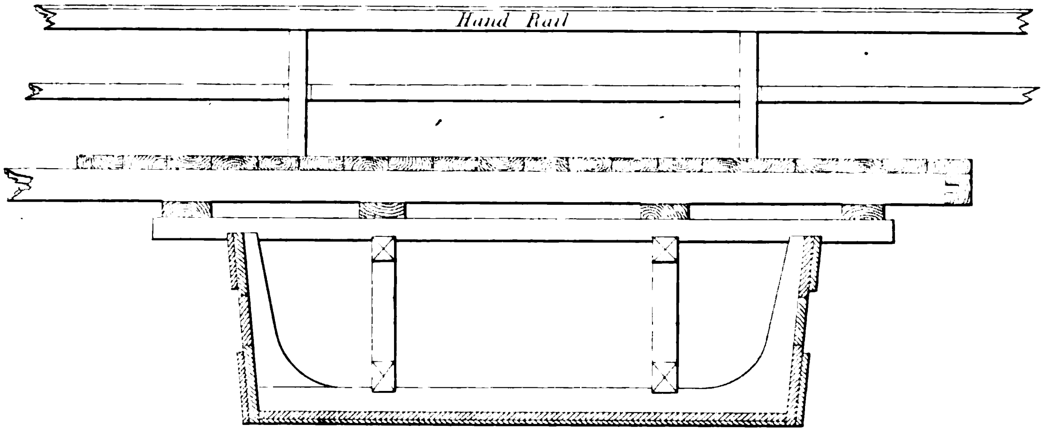

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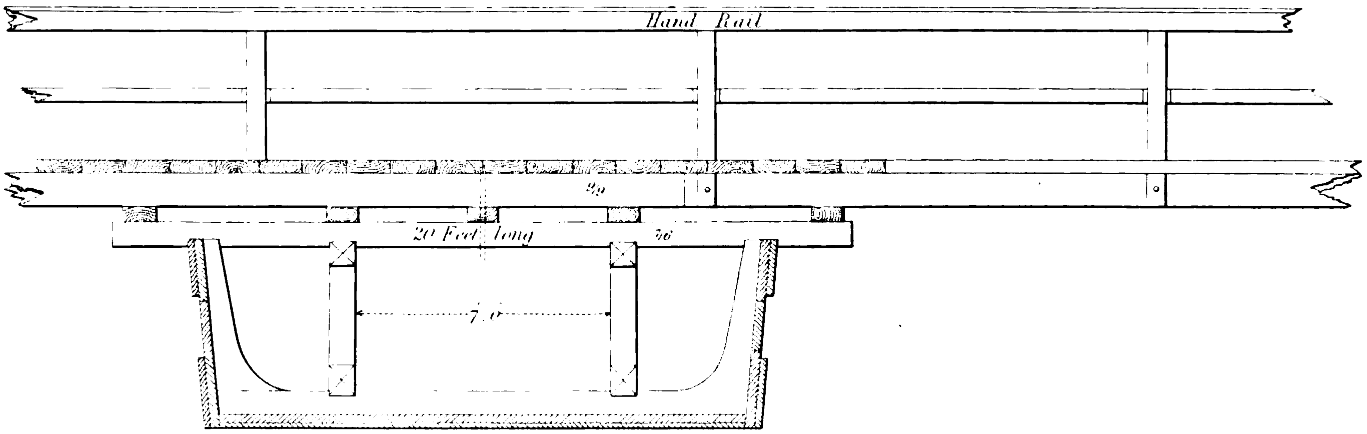
Fig. 3.



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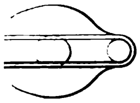
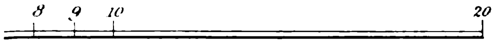


Fig. 7.



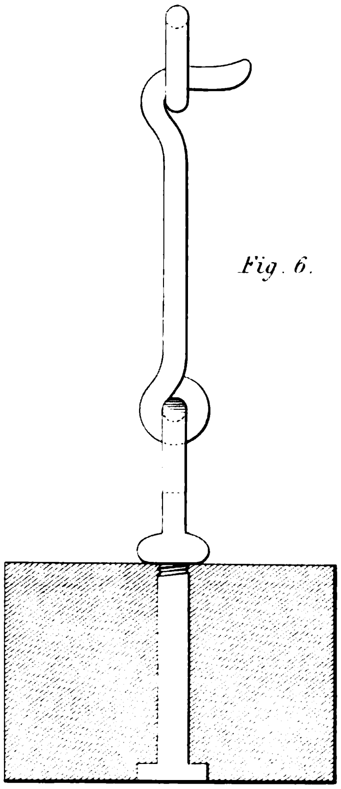


Fig. 6.

Section of the End Ships.

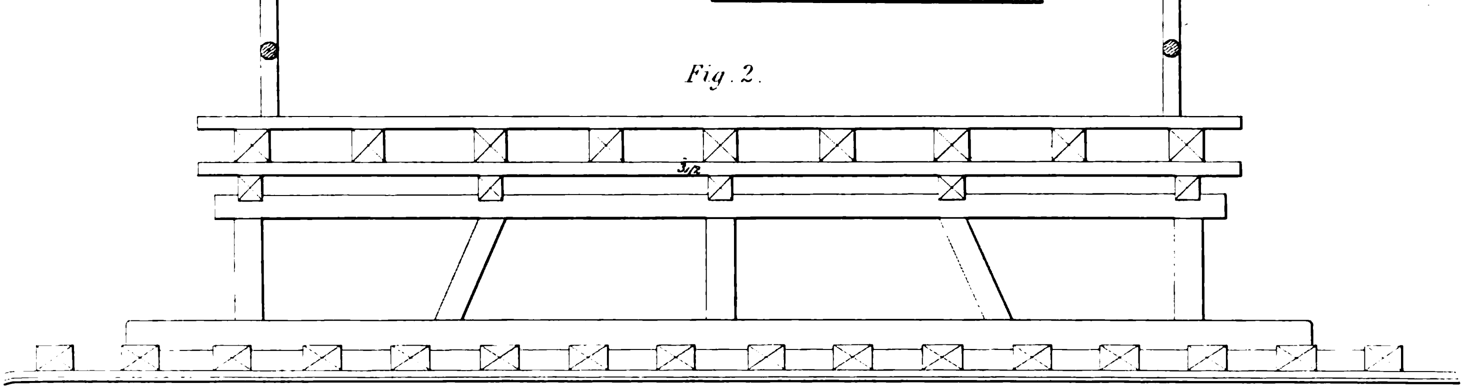
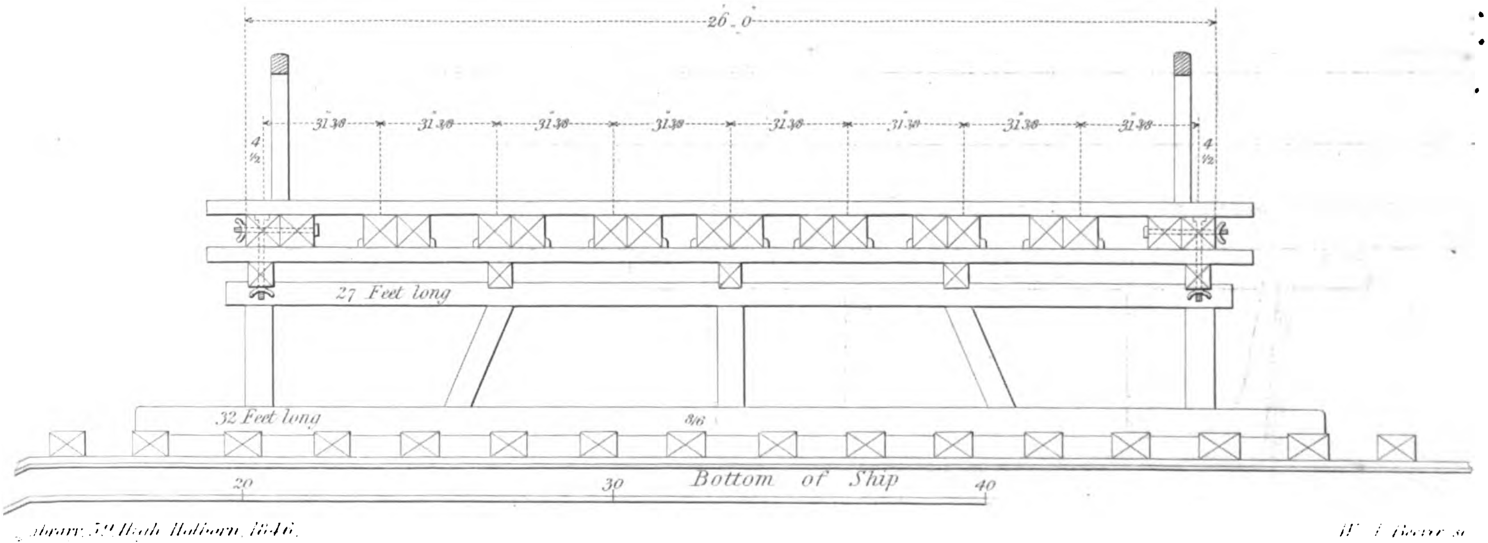


Fig. 2.

Bottom of Ship or Boat

of the Middle or Inside Ships.

Fig. 4.



...brary, 59 High Holborn, 1846.

W. J. B...r sc.

DESCRIPTION

OF A

WET DOCK AND OTHER WORKS,

PROPOSED TO BE CONSTRUCTED ON THE

SOUTH SIDE OF THE RIVER WEAR, AT SUNDERLAND,

IN THE COUNTY OF DURHAM.

BY JOHN MURRAY, M.Inst.C.E.

SUNDERLAND is situated at the mouth of the river Wear, contiguous to an important district of coals of first-rate quality. It ranks as the fourth port in the British empire, in respect to the aggregate amount of the tonnage of its ships. Its foreign trade is considerable, and great quantities of timber, hemp, &c., are imported for colliery and other purposes. Lime is extensively shipped for different parts of the east coast of England and Scotland. Ship-building is likewise very largely carried on, and upon the banks of the river there are large manufactories of glass, earthenware, iron, copperas, and other works. The Borough contains about 60,000 inhabitants.

The coal trade is the staple commodity of the port. It is of a peculiar nature, and is carried on in vessels of various tonnage. On account of the uncertainty of the winds, these frequently arrive in large fleets, each vessel requiring the loading of its cargo and fitting out to sea as speedily as possible for another voyage. A stranger would be surprised at the line of ships, tugged by steam-boats, passing out of the harbour about the time of high water, if the wind be favourable, for a London voyage, and if easterly winds have prevailed for a few days.

Nearly the whole trade of the port is transacted in the tideway of the river, from near its mouth for a distance of two miles upward. The navigable channel is often much contracted by the numerous ships which frequent the harbour; and as nearly all of them take the ground at low water, the shipment of coals is thereby much retarded.

At the beginning of the present century the shipping of the port was of an inferior class and small tonnage. The vessels were strongly built, and so constructed as to take little damage when lying aground; and the larger classes of ships, from a deficiency of water on the bar, took in the principal part of their cargoes in the roads from flat-bottomed keels. The rapid increase of trade, and the improvement of the river, have caused a complete change of things, and numerous ships now frequent it, ill adapted to withstand the strains to which they are necessarily subjected, especially if detained in the harbour by contrary winds; and in winter all of them are liable to injury by freshes and ice.

The formation of wet docks has therefore been for many years past a desideratum, and their construction will not only be of the greatest importance to the shipowner, coal-owner, and merchant, but will afford increased employment to an enterprizing population.

The principal collieries of the district are on the south side of the river, and the annual quantity of coals at the present time brought from them for shipment exceeds one million and a half of tons, which will be greatly augmented on the formation of a dock, by collieries now worked and others to be opened out, the owners of which will doubtless avail themselves of such improved accommodation. Much additional traffic is also anticipated in coals, coke, iron-stone, lead, and other merchandize, by the extension of railways to Bishop Auckland, and the higher parts of the Wear Valley, with its tributary dales, for the exportation thereof Sunderland is the natural outlet; and it is fair to expect a very great increase of trade for the importation of colonial produce, and from the exportation of the minerals of the county of Durham and the manufactures of Yorkshire and Lancashire.

Various schemes have at different times been projected, for making wet docks at Sunderland, by engineers of professional eminence. It has been generally allowed, that to meet the requirements of the port, a dock to be useful must be connected with the southern side of the river, which is the seat of trade, and the situation of the principal coal mines. With that view, Mr. Giles, in the year 1831, projected an extensive dock along the sea shore in front of the Town Moor, with a tidal basin, locks, and other outlets to communicate with the river Wear. The scheme was carried into parliament, and after a long discussion was rejected by a Committee. The Commissioners of the River, in the latter part of 1832, employed

Mr. Walker and Mr. George Rennie to give designs for a small dock on each side of the river, capable of extension as the necessities of the port might require.

The site chosen by those engineers for the south dock, was the same as that adopted by Mr. Giles, but the details of the plan were somewhat different. The north dock was intended to be formed on the low ground northward of the North Pier. These plans were deposited in Parliament, but they were abandoned in consequence of a notice of an injunction being served upon the Commissioners from various coal-owners and others, for a misapplication of their funds.

A dock, designed by Mr. Brunel, of about seven acres in extent, communicating through a small tidal basin with the river Wear, near its mouth, has been since carried into execution by a private company, on the north side of the river, upon low ground northward of the North Pier. A railway has been also formed to connect it with the Brandling Junction Railway, and by means of it with some collieries on the north side of the river, which bring their coals to the dock for shipment. It is therefore useful to some vessels which enter and take in their cargoes there, and for large vessels *lying up* during the months of winter. Its entrance, however, is much exposed to a range of sea during easterly gales, making it dangerous even to open the gates, and thus very often preventing light vessels from entering, or laden vessels departing from the dock.

Powers are now being sought to be obtained from parliament to construct a dock on the south side of the river, on the sites proposed by the engineers above mentioned, but with a new feature in the project, viz., a sea-tide basin and a southern outlet into Hendon Bay [a].

The dock is proposed to be constructed, chiefly, within the high-water mark, and in front of the Town Moor, which has been and is now rapidly wasting away by the action of the sea, exposing a nearly perpendicular clay cliff, about 35 feet in height. As many objections were raised before the parliamentary committee to Mr. Giles's scheme of a *glacis* or sea wall, care has been taken not to permit the present project to have any thing of the sort, but a sloping embankment, (similar to the existing beach,) to be formed between the dock and the sea, by depositing the stone and other matter excavated in constructing the works.

The erection of groynes in front of a part of the Town Moor, placed there some time since at the suggestion of the writer, and under his superintendence, has secured the ground at a trifling expense by collecting the sand and gravel, and causing the high-water mark to recede 150 feet further to the eastward.

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[a] The new dock is proposed to be formed by a company, of which Mr. Hudson, the member for the Borough, is chairman. The plans have been prepared by Mr. Robert Stephenson and the writer.

Groynes have been similarly applied to other parts of the coast of England and elsewhere with equal advantage. The north pier, built by the Commissioners of the River, has acted like a groyne on a large scale. A space of ground, upwards of 30 acres in extent, has been gained from the sea by means of it, and on which the north dock has been since constructed.

It is evident, therefore, that if a series of groynes were run out sufficiently far on the rocks from the Town Moor, much land might be gained from the sea, and if these groynes were built of masonry in a substantial manner, the land might be permanently reclaimed. It is, however, proposed to convert this space into water, in the shape of an extensive dock, by excavating the magnesian limestone, which would form the nucleus of the groynes and the connecting barrier between them. The sand and gravel, which are carried in considerable quantities by the flood tide setting southward, meeting with the resistance of these groynes, would be stopped and be deposited between them. Vessels might run, if they miss the harbour in a storm, upon this shelving shore, and would sustain less damage than by beating upon a large surface of rough rocks, as at present, and afterwards coming in contact with the cliffs of the Town Moor.

The plan of the projected dock gives an extent of 27½ acres of water, exclusive of the northern tidal basin of upwards of 2½ acres, and the southern or sea-tidal basin of rather more than 4 acres, making altogether an additional water surface of about 34 acres, which will be capable of accommodating upwards of 350 vessels always afloat. The rise of an ordinary spring tide at Sunderland is 14 feet 6 inches, (an equinoctial spring tide being 3 feet 9 inches higher,) and the rise of a neap tide is 6 feet; consequently, as the dock is to be made 6 feet deep under low water of spring tides, there will be in it 20 feet 6 inches of water at a spring, and 17 feet on a neap tide.

The western side of the dock is to be appropriated principally to coal staiths, the high ground adjacent being favourable for the purpose. It is proposed to run a long jetty into it, so as to give increased facility for the shipment of coal. A considerable space of ground on the Town Moor will be purchased as standing room for coal waggons. The Durham and Sunderland Railway station is contiguous, and other railways are projected by means of which the Durham and Helton collieries will have access to the dock.

The northern basin will communicate with the river by two openings, one of which points seaward, and is intended to be 45 feet wide; the other will point up stream, and is intended to be 100 feet wide, in its narrowest part. Between the basin and the dock there will be two inner passages of 45 and 60 feet wide, each with gates pointing inward.

Between the dock and the sea-tidal basin there are to be also two passages of 45 and 60 feet wide, with gates and similar passages on the south end of the tidal basin, with inward and seaward gates. This exit is to be protected from the sea by means of rough breakwaters of rubble stone, one on the east side nearly parallel with the entrance, and the other on the west side nearly square with it.

The portion of the advancing wave intercepted by them, will be mainly destroyed by the tidal harbour of eleven acres which it will have to expand over, and as the principal run of the wave will at all times be along the inner faces of both piers, the gates will be in comparatively still water. The southern passage between the gates and the pier-heads is proposed to be kept as deep as the dock by dredging and scouring.

It is also proposed to erect on the sea-shore, in a southerly direction from the site of the proposed dock, a series of groynes or jetties for the purpose of collecting sand and gravel between them; and when so warped up above the level of equinoctial spring tides, the Dock Company will be empowered by the bill to deposit between the groynes such ballast or other substances as they may deem expedient.

The estimated cost of making the dock, groynes, and the various other works intended to be constructed by virtue of the bill now before parliament, including the purchase of land and buildings, parliamentary and other expenses, amounts to the sum of £300,000.

The plan of this proposed dock was referred by the Lords of the Admiralty to Mr. Walker, requesting him to survey and report on its probable effect upon the present harbour, and in respect to other Admiralty interests. Mr. Walker's Report is dated 3rd January, 1846, and is appended.

In conformity with a wish expressed by the Commissioners of the River, the pier-heads, (which originally were designed to project into the river,) were set back without their parliamentary "Quay Line;" and the width of the river has been increased to comply with Mr. Walker's Report, at the western or principal entrance passage, by altering the quay from Thornhill's Slip, which will afford swinging room for vessels intending to enter the dock.

The grand feature of the scheme will be the exit to the south, (the want of which has been so much felt at Sunderland,) and which can be used when the present harbour's mouth is sealed by easterly and north-easterly winds. According to the soundings, and from the less *send* or lift of sea there, than upon the bar at the mouth of the river, an increased depth of 3 or 4 feet of water will with facility be obtained; the importance of which to the shipping and commerce of the district cannot be sufficiently appreciated, as undoubtedly by means of it Sunderland will become the first port, as to depth of water at its entrance, between the Humber and the Frith of Forth.

26, Parliament Street, Westminster,
April 20th, 1846.

MR. WALKER'S REPORT

ON A

PROPOSED WET DOCK AT SUNDERLAND.

23, Great George Street,
3rd January, 1846.

SIR,

THE plan of a proposed dock, on the south side of the river Wear, at Sunderland, having been referred to me by the Lords of the Admiralty, for my survey and report on its effect upon the present harbour and other Admiralty interests, I have visited Sunderland, surveyed the site intended to be converted into a dock, and taken the evidence of shipowners, pilots, and others, respecting the general scheme and the particular plan.

The Secretary of the Admiralty,
&c., &c., &c.

The want of a dock, or some other good accommodation for shipping in Sunderland, has long been felt, and various plans have been proposed; one so far back as 1794, by Mr. Dodd; another in 1807, by Mr. Jessop; another in 1832, by me; when Mr. George Rennie also reported his opinion. Nothing, however, was done until 1835, when a dock of six acres, with an entrance basin, was begun by Mr. Brunel, on the Monkwearmouth or north side, and finished in 1838. But little coal trade has been done in this dock, the collieries being chiefly on the south side of the river Wear, but it has been useful for the reception and fitting out of large new ships in the foreign trade, and during the winter months a great many vessels have been laid up in it. In 1844, Mr. Murray, the engineer to the harbour and river commissioners, and now one of the engineers to the proposed dock company, suggested a plan for the improvement of the harbour, on which I reported; but there were objections which caused the design to be dropped. Thus, the river and the Monkwearmouth dock form the whole of the shipping accommodation for the port of Sunderland, in which there are sometimes 300 coal-laden vessels. The harbour is notoriously bad; so shallow, that all the laden ships ground in it: the bottom is hard and irregular. Ships in the harbour are also subject to heavy *land* floods and *ice*, by which last cause £40,000 of damage is stated to have been done in one day[a].

The evidence states, that every vessel which takes cargo in Sunderland is more or less damaged; that almost every vessel which comes to Sunderland for a number of voyages has some of her timbers broken; that very few of the large coppered ships for the Mediterranean or other foreign ports take cargo at Sunderland, as the ship or the copper almost always gets damaged, as but few of the berths in the harbour have so much as 9 feet, and some of them only 4 feet at low water; that sometimes the whole trade of the port is at a stand, with two to three hundred laden vessels in it, owing to a want of water upon the bar; that the owners of large ships in the foreign trade cannot, although they belong to the port of Sunderland, bring their ships there for coal cargo, but send them to the Tyne (where there is 2 feet more water) and elsewhere; that this export trade of coal for the supply of steamers and otherwise is rapidly increasing, so that the evil is now more felt than formerly; that if there were water and safety, ships for the East and West Indies would go to Sunderland, as the best coal for steam-vessels is from pits that are round *Sunderland*, which for the above cause is not supplied for export to the extent it would otherwise be; and that for these reasons, the trade of the Wear has been nearly stationary for some time, while that of other ports has been rapidly increasing.

Strong illustrations of all these evils were given to me on my late as well as on my former visit, but I think it unnecessary to extend the report by detailing them, even if their lordships were not aware of the general facts, which I presume they are, and that a dock in which vessels are always kept afloat, and are at one level secure within gates, has great advantages over almost any tidal harbour, and particularly so very bad a harbour as I have now described. I would not from this have it to be concluded that the harbour of Sunderland is not capable of improvement; I think the contrary; but to whatever extent this may be carried, it will always be inferior to the dock, which will be used generally, except on cases where the present railways and staiths, some of which have been laid and erected at great expense, communicate with the harbour.

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[a] This was during the winter of 1841,

To relieve the harbour of its occasional crowds, thus giving better room for those that remain, will of itself be of great advantage.

On *principle*, therefore, there is every public argument in favour of the dock scheme, and none that I can see against it.

The new dock is proposed to be formed by a dock company, of which Mr. Hudson, the member of the town, is chairman. His wealth and influence are additional guarantees that the scheme will be carried through. I have not gone at all into an examination of the estimate of costs, which Mr. Murray states to be £200,000, exclusive of purchases and parliamentary expenses, (which are likely to be small,) because if their lordships think that any security should be given for the completion of the work, in case of cost exceeding expectation, there would, I apprehend, be no difficulty in giving it. The plans have been prepared by Mr. Robert Stephenson (the eminent engineer) and Mr. Murray.

The latter gentleman has been engineer to the River and Harbour Trust for fifteen years[a], during which time the erection of the new North Pier, the removal of the Lighthouse, and other interesting works, have been successfully executed by him.

At high water the sea washes the foot of a clay bank, which is about 35 feet high, and extends from the river southward for the length of the town.

Between the top of this bank and the town is the Town Moor. The clay bank, when washed away by the tide, exposes the surface of a limestone rock, which inclines upwards from low water, and is in width from four to six hundred yards.

Out of the heretofore valueless rock formation the dock and basins are to be excavated, the excavation being applied to raise the space round the dock, &c., to the proper level for quays.

The form of the docks, its basins and approaches, will be best understood from the plan. The north entrance is out of the river Wear, between the inner end of the south pier and the town, through two passages, one of which points to the north-eastward or seaward, and is proposed to be 45 feet wide; the other, which points up the stream, is 80 feet wide. These form open passages into an entrance basin of two acres and a half, between which basin and the dock are two inner passages of 60 and 45 feet wide, with *gates* pointing inwards or towards the dock. The dock is 27½ acres area, therefore capable, at 10 ships per acre, of receiving 275 ships. The committee calculated on 350, of from 200 to 300 tons.

The lift of a spring tide being only 14 feet 6 inches, the dock is to be 6 feet under low water, giving 20 feet 6 inches water in the dock on a spring, and

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[a] Sir John Rennie was consulting engineer during six of the fifteen years.

17 feet on a neap tide. The above depths can be maintained in the dock, but the depth at the bar at the harbour mouth is two feet less, so that with the " scud " of sea during a north-east gale a vessel drawing more than 14 feet cannot venture over the bar with safety. To have the dock so much deeper than the approach to it would be of little use, and yet, from the great draught of ships from foreign ports, it would be very advisable to have not less than 17 feet at neap and 20 at spring tides. The engineers propose to accomplish this by sending laden vessels chiefly out at the south end through a tidal basin of 4½ acres, with two openings, one having gates of 60 feet, and the other of 45 feet, between the dock and it and other similar gates between the basin and the outer entrance. The outer entrance or rather *exit* points south, south-east nearly[a], and is to be formed by means of rough breakwaters, one on the east side, nearly parallel with the entrance, and the other on the west side, nearly square with it. This southern passage is proposed to be as deep as the dock, and to be kept to that level by *dredging* and *scouring*. This very important feature of the plan, (the southern passage,) is so far as I remember *new;* and if it can be effected as proposed, will be a great convenience, by giving laden ships two to four feet more water than can at present be depended on; starting them in the right direction for the south, when the wind is fair, also leaving the Wear or harbour entrance clear for the present harbour, and the entrance of light ships into the docks.

As thus neither the dock nor the works at the south end interfere with the river, it is not within my province to be very particular in the detail of them. They are on a scale which consists with the character of Sunderland, now the fourth port in the kingdom for the amount of shipping, and they will tend to raise it higher. Various opinions were given as to the position of the southern passage, and alterations were suggested on account of the entrance, as it is drawn, being too near the shore; but as its removal outwards, or pointing it more to the eastward, would open it to a heavy sea, from which the entrance, even as now proposed, will not be free, and as vessels can in all cases, where there is the least danger, have the aid of the steam-tug, I should not feel justified without a more detailed inquiry in suggesting an alteration. The Hendon Rock, which is a mile and a half off, with six feet over it at low water, will require to be beaconed or buoyed.

The northern entrance will interfere with the passage *up* the harbour, as the river is *narrow*, and as Mr. Murray thinks that the ships will generally enter by the western passage, (that which points upwards,) they must swing before entering, and will cause the removal of the lower tier in the harbour. Although ships in going up the harbour hug the north shore, opposite the point where the entrance of the dock is proposed, it will, I think, be requisite to *widen* the river here, as *swinging* in a strong *tideway* requires considerable room. The harbour and river commissioners may expect to have a clause in the act for this purpose. Light ships entering by the eastern passage will not require to be swung, and will be less in the way both in going in and out.

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[a] The bearings are all by compass.

The rate upon coal vessels is proposed to be three halfpence per ton register, or 25*s*. for a ship of 200 tons, which is less than the average damage which a ship takes at each voyage by grounding.

Mr. Murray stated that the basin is to be kept clear by dredging, so that sand will not be scoured into the river, and that there will be no objection to a clause in the bill to prevent the scouring, and to maintain the level of the river opposite and near to the entrances. The Wearmouth Dock Act contains some stringent clauses of control over that river, and harbour commissioners over that dock company, which, with modifications, will be useful in the proposed dock act; but I do not find any clause giving the commissioners, or their harbour masters, the absolute management of vessels intending to enter the dock, until they shall be completely out of the river, or of vessels leaving the dock after they approach the river.

I submit that the appointment and continuance of the officers and men who have this work to do, should be with the commissioners, although the charge be ultimately borne by the dock company.

It is very satisfactory to me, after the remarks I felt called upon to make on Mr. Murray's plan for improving the harbour, to have so much to approve and so little to object to in the present design. Neither he, nor those who at the time agreed in opinion with him, are, I hope, now sorry that the execution of the former measure was prevented through the interference of their lordships.

My opinion upon the whole is—

1st. That their lordships should consent to the dock as proposed.

2nd. That the bill should contain clauses for the following purposes, viz.:—

For preventing obstructions in the river during the execution of the works and afterwards.

For widening the river opposite the proposed northern entrance, so that the present facility for ships passing up or down the river be not interfered with.

For preventing scouring through the sluices of the north entrance.

For giving the river commissioners the appointment and power of discharging the dock company officers, who are to take ships from the river in the northern basin and the reverse, the commissioners having the absolute direction and control of the ships in the river, and the times of their being removed into the river.

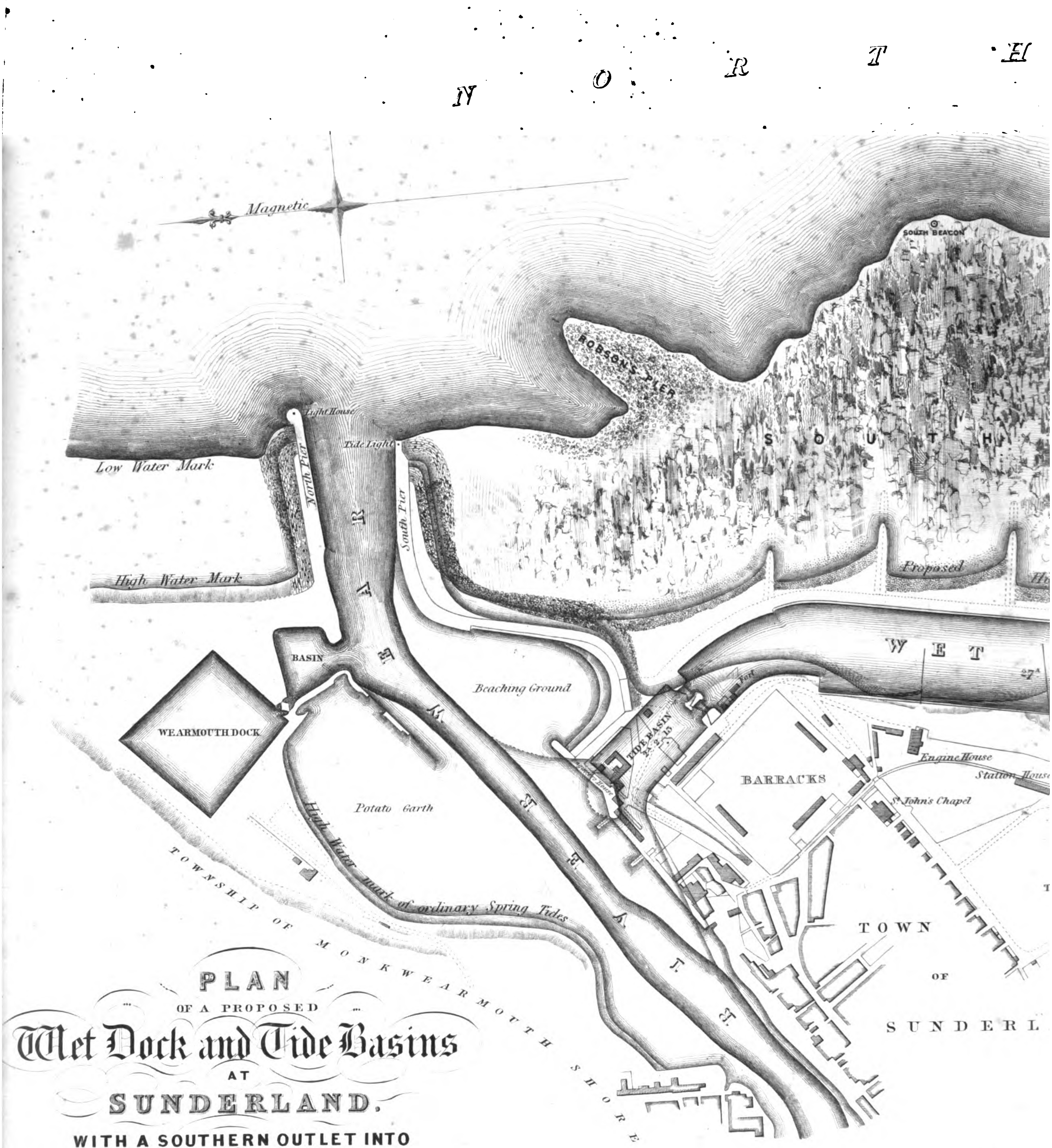
For obliging the dock company to keep the river opposite their entrances to the full depth of the other parts of the channel which are beyond the influence of the entrance.

For securing the completion of the works according to the present design, any alterations to be approved before being made.

For fixing a beacon or buoy on Hendon Rock and elsewhere, if required for the safety of shipping.

For erecting convenient bridges over the entrances, so that the passage between the town and the South Pier may not be interrupted beyond what is necessary.

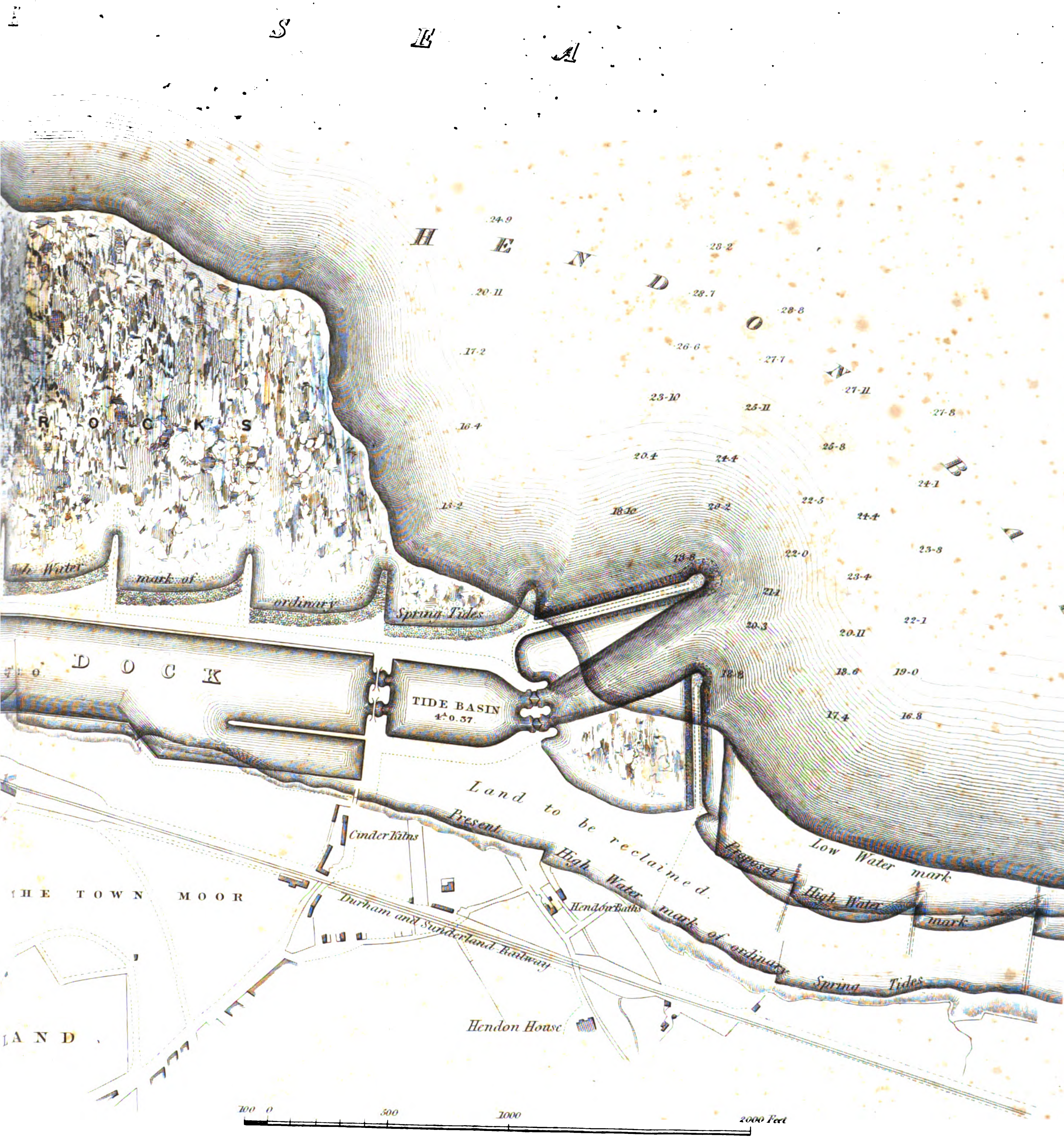
I have the honour to be, Sir,
Your obedient Servant,
Js. WALKER.



PLAN
OF A PROPOSED
Wet Dock and Tide Basins
AT
SUNDERLAND.
WITH A SOUTHERN OUTLET INTO
HENDON BAY.

JOINT ENGINEERS.

Robert Stephenson Esqr. & John Murray Esqr.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THE TOWN MOOR
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